20th Century Fox Special Collector's Cover

Popular Mechanics

[HOW ~~YOUR~~ MARS WORLD WORKS]

DO A LITTLE EXPLORATION OF YOUR OWN.

DISCOVER THE NEW LOGO

TURN THE PAGE

THE MARTIAN

Premieres October 2 (on Earth)

Get a behind-the-scenes look at:
THE HABITAT • HERMES SPACECRAFT • THE ROVER

EXPLORE RIDLEY SCOTT'S NEW FILM

Shazam this cover.

TURN TO PAGE 13 TO SEE HOW.


A RIDLEY SCOTT FILM
BRING
HIM
HOME
MATT DAMON
THE MARTIAN
MUSIC BY HARRY GREGSON-WILLIAMS PRODUCED BY SIMON KINBERG RIDLEY SCOTT MICHAEL SCHAEFER ADITYA SOOD MARK HUFFAM BASED UPON THE NOVEL BY ANDY WEIR
IN REAL D 3D & DIGITAL 3D
SEE IT ON THE IMAX LARGE FORMAT SCREEN
#TheMartian
TheMartianMovie.com
OCTOBER 2
SCREENPLAY BY DREW GODDARD DIRECTED BY RIDLEY SCOTT

The Future *of the* American Home

- **Is Your Home Secure?**
- Can You Go Solar?
- **Are You Wasting Money on Energy?**
- Do You Need a New Toilet?

NEW LOGO

POPULAR MECHANICS

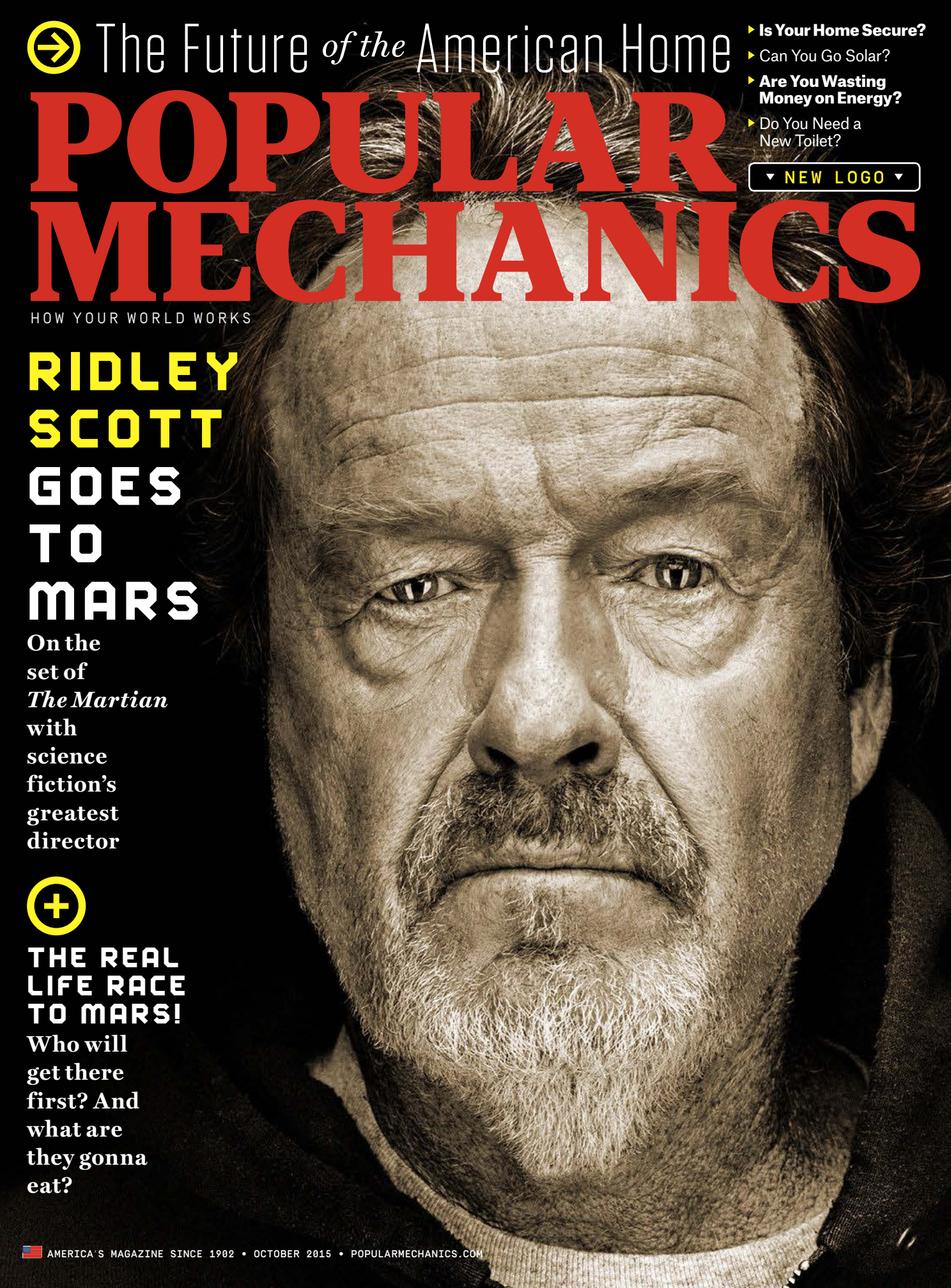
HOW YOUR WORLD WORKS

RIDLEY SCOTT GOES TO MARS

On the set of *The Martian* with science fiction's greatest director

THE REAL LIFE RACE TO MARS!

Who will get there first? And what are they gonna eat?



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POPULAR MECHANICS

CONTENTS

OCTOBER • 2015

4 From the Editor
6 The Reader Page
7 Letters
8 Calendar
14 Shop Notes
16 Great New Stuff

HOW YOUR WORLD WORKS

19 The newly discovered part of your brain that could help cure disease
22 An international arms race in the Arctic
24 Why the best foods are spoiled
26 The end of work email
28 Great Unknowns

SKILLS

33 Firewood: A guide to the love and labor of splitting logs
36 How to work with reclaimed wood
38 **Tool Test:** Electric blowers
40 **Things Come Apart:** Pitching machine
42 Drink like your ancestors
50 Ask Roy

CARS

53 The Mazda Miata gets mean. Finally.
58 Four great aftermarket gadgets for your car
60 **Reviews:** The latest from Nissan, Cadillac, and Subaru

REPORT: CUBA

62 Fifty-five years of isolation have turned the people of Cuba into a nation of self-sufficient makers

A BEAUTIFUL THING

70 **Chelsea Miller Knives:** A rasp once used on horse hooves now helps you make dinner

PROJECT

107 A standing desk you'll be proud to put in your office

POPULAR MECHANICS FOR KIDS

115 A time capsule to last for decades

COVER STORY

72
RIDLEY ON MARS

One of the most successful and ambitious directors of our time takes on one of the most popular books of the Internet: *The Martian*. A reckoning.

BY TOM CHIARELLA

Ridley Scott, earthbound, on the set of *The Martian*.

78
THE SCIENTIFIC COMPANION: MARS

A comprehensive (yet brief!) guide to our efforts to land on the Red Planet—and how we'll survive once we do.

82
THE FUTURE OF THE AMERICAN HOME

Our annual roundup of the innovations reshaping the domestic environment, featuring:

84
SECURITY
The cameras, locks, and even guns making our homes safer than ever.

90
TECH
About these Nest thermostats . . . The early adopter's dilemma.
By Alexander George

94
TOILETS
Set down the wet wipes and consider the bidet.
By Andy Isaacson

96
SOLAR
Will we ever experience the full promise of renewable energy?
By Eric Kester

102
REMODELING
The joy—and peril—of fixing up an old house.
By Ryan D'Agostino

ON THE COVER: Ridley Scott photographed by Robert Maxwell. (Subscriber cover illustration by Tavis Coburn.)

From the Editor

D'JOU SEE THE NEW LOGO?

You might have noticed the new logo on the cover of this issue of Popular Mechanics. The bold letters comprised in our name, the clean lines, the capital letters.

Or maybe you didn't notice. That would be just as well, because it would signal that our new logo suits us, that it's a natural fit. That was the idea. The typographer with whom we collaborated to create it, Henrik Kubel, is the current master of making the alphabet look beautiful in any language—his recent projects include everything from new fonts for *The New York Times Magazine* to a redesign of the signage in the entire Moscow subway system. In the rarefied world of typography, the guy's an animal. For our new logo, we looked at our history and found that some of the logos from long ago possessed more authority and energy than the current version. The new one is a direct descendant of its ancestors, but interpreted for modern times. Kind of like the magazine itself.

Why change it? Why not leave well enough alone? Because that's not the Popular Mechanics way, if you think about it. People who read Popular Mechanics don't leave well enough alone. You make stuff better—sometimes just a tiny bit better, but better nonetheless. It's why our new Shop Notes section, with its quick ideas for improving everyday tasks, works so well. (Truth be told, it's actually an old section. They first started publishing it around 1903.) It's why we devote so much of this issue to small but significant ways you can make your home better—more secure, more energy-efficient, more fun. And it's why we're running associate editor Kevin Dupzyk's story on Cuba ("Nothing Is Impossible for Those Who Fight," page 62), in which he travels to the country before normalization sets in, to observe the way its people build things as a way to survive. Reading about the resourcefulness and creativity of the Cuban people reminded us of ourselves. They make stuff better out of necessity.

So, anyway: our new logo. We are proud to unveil it. I hope you either love it—or didn't notice it at all.

RYAN D'AGOSTINO
Editor in Chief

POPULAR MECHANICS
SINCE 1902

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The Reader Page

REMEMBER: We give $100 for reader projects that we publish, and $50 for original reader tips that we run. You can send both to editor@popularmechanics.com.

PROJECT OF THE MONTH

A CHICKEN-COOP TRACTOR

Mike Robidoux of East Haddam, Connecticut, is an operating engineer at a power plant by trade, woodworker by hobby, and now chicken farmer by his wife's impulse. When Mike's wife came home with eight chicks this past April, they had nowhere to keep them but in a box in their basement. After failing to find a coop that met his construction standards, Robidoux, who's built decks and house additions in the past, decided to build one on his own. He drew up plans, and over the course of two weekends in May, he used halved 2 x 4s to build a 14-foot-long, 6-foot-tall coop and chicken run. Robidoux outfitted the project with multiple entry points—including a full-sized door in the back, hinged roofing, and a small window in the chicken wire to access and let down the front door of the coop—so that he, his wife, and their two young sons could easily tend to the chickens. The coop is also equipped with a set of wheels, so the family can relocate the chickens throughout their 4 acres without having to personally herd the birds.

READER PROJECT: VINTAGE


Build PM's 'Boonie Bug'

Jerry Sanders had already been a fan of customized VW vans when our own modified take on the classic chassis, dubbed the Boonie Bug, a hybrid camper/station wagon that you could build on your own, ran in the March 1974 issue. Sanders ponied up the $15 for the full plans (plus a little more for an old VW Transporter chassis), and spent two years making the mashup vehicle. Sanders's Boonie earned several awards at local auto shows and starred in era-defining photos like this one, before Sanders eventually sold it in 1984, airbrushed mural and all.

THE HELL IS THIS THING?

I have this device and no one seems to know what it is. I am 70 years old, have been around machinery all of my adult life, and have even asked some of the local old-timers and am still coming up blank. Can you or your readers identify it?

Stephen Gooden
Inman, South Carolina

EDITOR'S NOTE: ***Stephen's submission stumped even our longtime home editor, Roy Berendsohn, so we took it to Facebook and Twitter.***

THE MAJORITY CONSENSUS: A Band-Saw-Blade Jig

I remember my granddad having something that looked like this at his sawmill in the 1950s. He used the fixture to clamp and align band-saw blades while he welded them.

Keyser Söze, *via Facebook*

That is a jig to hold a band-saw blade. The blade would be arranged diagonally from lower left to upper right and held in place under the two "clamps." The grinding wheel (not pictured) would fit on a vertical shaft just above the round object on the left. The adjusting wheels control the movement of the grinding wheel while sharpening.

Larry Wagar, *via Facebook*

It's a fixture for aligning and soldering band-saw blades. The wheels allow for fine adjustment in three dimensions to ensure a straight and smooth-running blade.

Adam Wisnia, *via Facebook*

AND ONE IDEA FROM THIS COMEDIAN:
Left-handed screwdriver.
@Bigkozi, *via Twitter*

If anyone disagrees with what your fellow readers think this contraption is or does, give us a shout at editor@popularmechanics.com.

Letters

You can always get our attention and share your questions, projects, or pictures of your remaining fingers on Twitter and Instagram using #popularmechanics.

WE TEACH YOU. YOU TEACH US.

QUIET A NOISY REFRIGERATOR

I recently woke up one morning to hear my fridge making a loud vibrating noise. I pulled it out and cleaned the coils and motor, but it was still making a racket. Then I remembered your story on a disassembled fridge ("Taking Things Apart," March) showing how a thermostat controls a fan that blows cold air from the freezer into the fridge. I pulled the panel off the back of the inside of the freezer and tightened the fan, which had come loose in its mount. Now the fridge runs smoothly.

Brian Miller, *Eagle, Idaho*

GET THE BEST PRICE ON A CAR

One of your tips for buying a car ("How to Buy a Car," July/August) talks about shopping in the fall when new models come out. That was truer in the '50s. Know that dealers today have monthly quotas to meet and can get panicky on the last Saturday of the month. If one wants a used car, find three cars that would suffice from three different dealerships during the week leading up to that last Saturday. Don't discuss price with them. Instead, tell the dealers to call you around 3:00 p.m. on Saturday with their best offer and then play the salesmen against each other. *That* is the way to buy a car at the lowest possible price.

Tom Furlong, *Oklahoma City*

PROPERLY WIELD YOUR BELOVED BAT

Remember when using the Louisville Slugger ("A Beautiful Thing," July/August): trademark up! In grade school we only had one bat. If you didn't hold it so that the trademark faced up, the bat could break and you'd be chased off the playground.

Jim Glascock, *Location withheld*

EDITOR'S NOTE: ***Jim's right. Slugger's trademark is on the weak, flat-grained side of the bat. If it faces the ground or the sky when you swing, you'll make contact on the tight-grained sweet spot. That is, if you make contact.***

A TWEET WE'RE ONLY HALF SERIOUSLY TAKING UNDER ADVISEMENT

#PopularMechanics should rate yard-tool-repair difficulty with number of fingers, each representing the likelihood of losing one.

@QuinnOCallaghan

Letters to the editor can be emailed to **editor@popularmechanics.com.** Include your full name and address. Letters may be edited for length and clarity. **CUSTOMER SERVICE/SUBSCRIPTIONS online:** service.popularmechanics.com; **email:** popcustserv@cdsfulfillment.com; **mail:** Popular Mechanics, P.O. Box 6000, Harlan, IA 51593; **subscribe:** subscribe.popularmechanics.com.

Calendar / OCTOBER

How to get the most out of your month.

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
				1	2 National Manufacturing Day. Also, that movie made by the guy on the cover of this magazine? It comes out today.	
4	5	6 Postseason baseball begins. You can start paying attention again.	7 Hockey season starts today, with Original Six matchups between New York and Chicago, and Montreal and Toronto.	8	9 Apple fanboy mania and Oscar-bait buzz converge in *Steve Jobs,* out today, with Michael Fassbender as Jobs.	10
11	12 Columbus Day. Honor the accidental discovery of North America by trying to go all day without using GPS.	13 The November issue of Popular Mechanics hits newsstands.			16 Tom Hanks and Steven Spielberg give us the Cold War thriller we've been waiting for with *Bridge of Spies.*	17 Use the weekend to build yourself a standing desk—it's good for you. Plans are on page 107.
18	19 Steel yourself for explaining over and over again to people that, yes, you're now working at a standing desk.	20	21 On the exact day that Doc and Marty traveled to in *Back to the Future Part II,* Lexus is unveiling a hoverboard prototype.	22 Leaf cleanup tip No. 1: If you're raking, build your pile on a tarp for easy disposal.	23 Leaf cleanup tip No. 2: If you're using a mower to mulch, empty the bag of clippings and leaves onto a tarp for easy spreading.	24 Leaf cleanup tip No. 3: Or just blow them into the neighbor's yard with one of the new blowers we tested on page 38.
25 Watch competitors aim for chainsaw glory during Stihl's Timbersports Championships on ABC.	26	27 Basketball's back.	28	29	30	31 Halloween. Tricks over treats.

FRI 10/2

THE ONLY MADE-UP HOLIDAY WE ENDORSE

Manufacturing Day is a concerted effort by large-scale makers to show off the beauty of American industry. Manufacturers across the country will open their doors today for free tours of their facilities. Find a local event at mfgday.com/events.

10/13

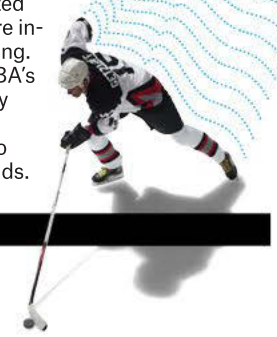
IN NEXT MONTH'S ISSUE

THE BREAKTHROUGH AWARDS
Our annual celebration of the people and technology changing our world, including computer chips made of wood and, yes, the Pope.

WED 10/7 TUES 10/27

NEW SPORTS TECHNOLOGY

The data and technology revolution in sports continues as the NHL is expanding its enhanced stats database and is expected to incorporate more in-game player tracking. Meanwhile, the NBA's streamlined Replay Center is reducing play-review time to less than 42 seconds.



SUN 10/31

HOW TO MAKE A TOILET-PAPER GUN

For your delinquent adolescent (or yourself) to terrorize the neighborhood with, use duct tape to fasten a paint roller onto the top of the tube end of a cordless leaf blower. Slide a roll of toilet paper on the roller. Aim for the trees and let it rip.

20th Century Fox
Special Collector's Cover

TAKE A TRIP TO MARS

EXPLORE RIDLEY SCOTT'S *THE MARTIAN* WITH SHAZAM

Go behind the scenes with an inside look at The Martian Habitat and Rover.

See Mark Watney's interview with the crew of the Hermes.

Watch exclusive footage and more.

SHAZAM THE COLLECTOR'S COVER FOR EXCLUSIVE CONTENT

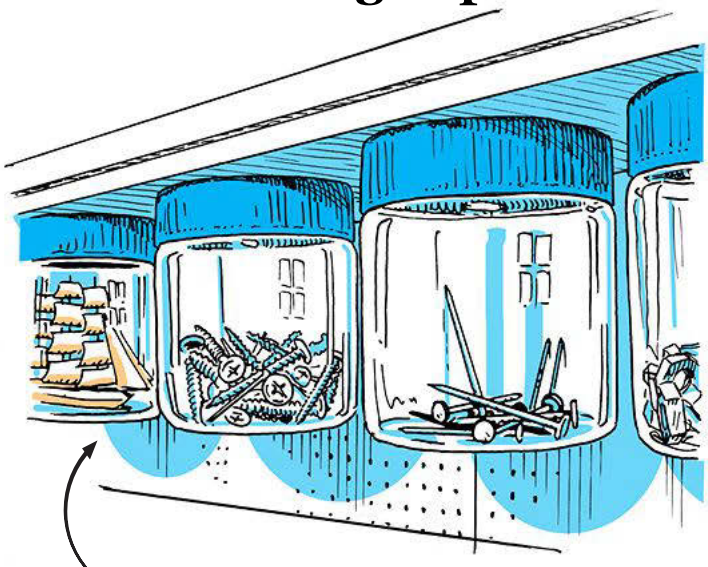
DOWNLOAD the latest version of the SHAZAM APP in the App Store or Google Play

USE THE IMAGE SCANNER in the top left corner of the SHAZAM APP to SCAN the COVER IMAGE

Shop Notes

EASY WAYS TO DO HARD THINGS

Make the Most of Storage Spaces

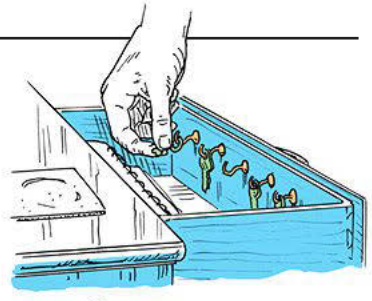


Jars Allow Both Sides of Shelf to Be Used

Glass jars are handy for storing fittings, fasteners, and more. Attaching them to the underside of a shelf keeps them out of the way. Simply drill two holes in a jar lid and screw it into the underside of a shelf. Screw the jar into the lid for storage. Baby food, jam, and mayonnaise jars are good sizes to consider. Clean them first.

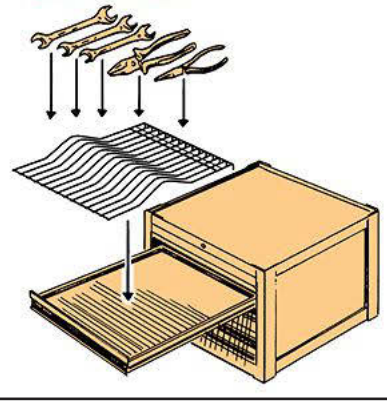
Cup Hooks Organize Keys in Drawer

Everyone has a cluttering drawer full of keys that can't be thrown away but are rarely used. Cup hooks inserted on the inside of the drawer front hang keys neatly and free up space.



Wire Shelf Becomes Tool Organizer

The YouTube channel Bushcraft-arizona found a modified wire shelf to be useful for segregating different types of wrenches while saving space. First, cut the shelf to fit into a toolbox drawer. Then fix it in a clamp and introduce a bend so that it rises up off the bottom of the drawer. Store wrenches on their sides between the wires.



PRACTICAL USES FOR MAGNETS AROUND THE WORKSHOP

DETERMINE THE TYPE OF METAL UNDER A LAYER OF PAINT

It's necessary to use cutting fluid when drilling steel but optional when drilling aluminum. Under paint, how can you determine which is which? A magnet clings to steel but not to aluminum.

HOLD SMALL FASTENERS ALL THE WAY TO THE HARDWARE STORE

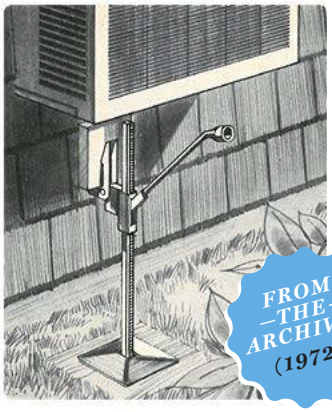
Taking a fastener to the hardware store can make for a perilous journey: Small screws are easy to lose. A small button magnet in one's breast pocket corrals them.

KEEP CANISTERS FROM FALLING OFF VIBRATING WORK SURFACES

The vibration of a motor can cause an oilcan or other light canister to fall off a surface while unattended. Provided the surface is metal, affixing a magnet to the canister with a rubber band or string will keep it in place.

Make a Bucket Slosh-Proof

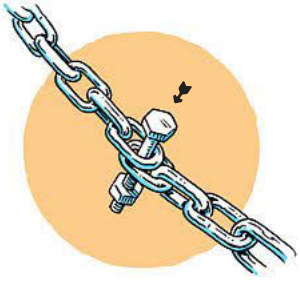
To eliminate any chance of dripping when carrying sensitive liquids in a bucket, line the bucket with a garbage bag. Fill the bucket with the liquid, then tie off the bag, sealing the contents inside.



FROM THE ARCHIVES (1972!)

Jack Overcomes Rust

When removing an air-conditioning unit rusted to its steel supports, break the rust seal by lifting each outside corner with a car jack. A length of 2 x 4 facilitates the lift.



A Hack for Broken Chains

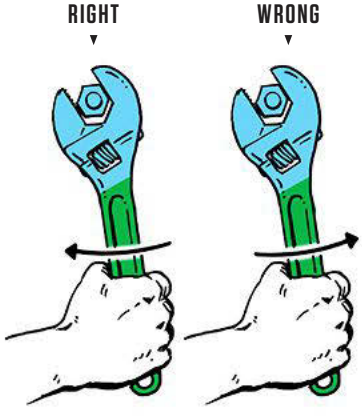
When your chain suffers a broken link, a temporary fix avoids an immediate trip to the hardware store: Remove the broken link so that two disconnected but intact links remain. Select a nut and bolt whose shank fits through the chain links but whose head does not. Use it to join the two good links, reuniting the broken chain.

ILLUSTRATIONS BY TED SLAMPYAK

REPORT-COVER GRIP SAFELY STORES HACKSAW BLADES

The U-shaped slide grips used to bind paper reports slip easily over hacksaw blades. So covered, blades can be stored without risk of dulling.

We are always looking for clever solutions to everyday problems. Email your shop notes to editor@popularmechanics.com and we'll pay $50 if we print them.



• SHOP SAFETY NOTE •

Use a Crescent Wrench Pain-Free

A Crescent wrench is an amazingly versatile tool—except for its propensity to slip off a nut, which can lead to injury. This is usually due to operator error. Two tips keep hands safe and nuts tight. First, pull the wrench, don't push it. Second, make sure the fixed jaw is applying the force—the adjustable jaw can come loose under pressure. In sum, this means putting the fixed jaw on the far side of the nut from your body, and pulling the wrench handle in the clockwise direction.

FOOD COLORING REVEALS TOILET TROUBLE

Condensation can easily be mistaken for a leaky toilet, and vice versa. Add food coloring to the tank and see if it ends up on the floor. If it does, call a plumber.

Revivify Down Bedclothes

Over time down blankets, sleeping bags, and comforters lose effectiveness as the air pockets in their insulation collapse. A spin in the dryer with a few tennis balls pulverizes matted clumps of down, reopening air pockets and restoring usefulness.

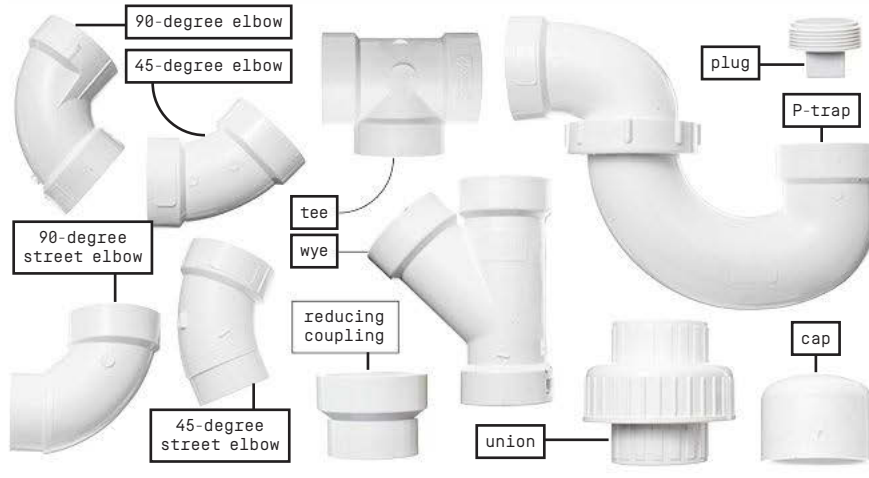
A Primer on Plumbing

Plumbing is invisible until it fails. Upon inspection it's a morass of different pipes and arachnoid fittings. Use this handy guide to avoid confusion and prevent grisly plumbing disasters.

MATERIALS

	GALVANIZED STEEL	COPPER	POLYVINYL CHLORIDE (PVC)	CROSS-LINKED POLYETHYLENE (PEX)	POLY-PROPYLENE (PP)
ADVANTAGES	Inexpensive, durable	Lightweight, corrosion-resistant	Inexpensive, lightweight, easy to use	Flexible, easy to join, lower propensity to leak	Durable, minimal risk of chemical exposure
DISADVANTAGES	Develops lime deposits in alkaline water	Expensive, may require soldering tools, may get stolen	Limited to uses that stay below 140 degrees Fahrenheit, like drainage and wastewater	Damaged by UV light	Expensive, requires special tools
JOINING	Pipe is threaded, and joints are sealed with pipe-joint compound or tape.	Copper pipe is traditionally soldered, but modern compression fittings create solderless joints, though they sometimes require special tools.	Cut pipe to length with a saw, then join to fittings with adhesive. Also accepts compression fittings, like copper.	After a fitting has been inserted into the pipe, a special crimping tool clamps a ring around it, forming a seal.	A heating tool is used to semi-liquefy the ends of the pipe to be joined. They are then hand-pressed together.

FITTINGS

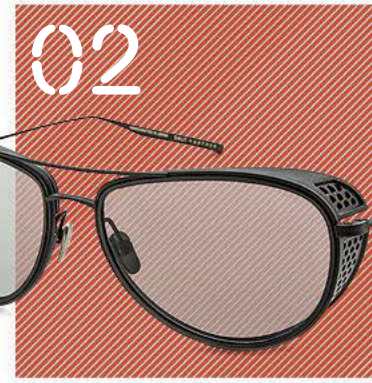


PHOTOGRAPHS BY BEN GOLDSTEIN

Great New Stuff

The things you need in your life this month.

The two-piece construction of the wheels, a recycled plastic core coated in urethane made from 30 percent vegetable oil, lets them roll over gravel and potholes.



01

BUREO MINNOW COMPLETE CRUISER

Tiny skateboards, like this 25-incher, are why skateboarding is great. So small that you'll actually carry it around, it turns sidewalks and, if you're brave, airport terminals into stages for carving. The Minnow's deck is made from discarded fishing nets (about 30 square feet of would-be trash goes into each board), so it flexes more than regular plastic or wood. **$149**

02

SALT X AETHER SCOUT SUNGLASSES

Long motorcycle trip, first fuel stop. You unbuckle your helmet and shake out the niggling discomforts—loosen the glove you cinched too tight, reinsert that loose earplug. The worst: Your helmet has been digging your sunglasses into your head. The Scout fixes that last one for good. Its thin titanium temples and nose pads fit comfortably inside a helmet, sparing you those red marks on your face. When worn with open-face helmets, the side shields keep the wind from dislodging your contact lenses at 90 mph. **$600**

03

DEVIALET PHANTOM WIRELESS SPEAKER

Ignore the Sputnik prototype exterior and wait for the bass notes to hit. That's when you see the side-mounted subwoofers move like pistons at high rpm, sending out flawless sound loud enough that you'll feel the vibrations in your sternum. Speakers aren't supposed to engage so many senses. **$1,990**

04

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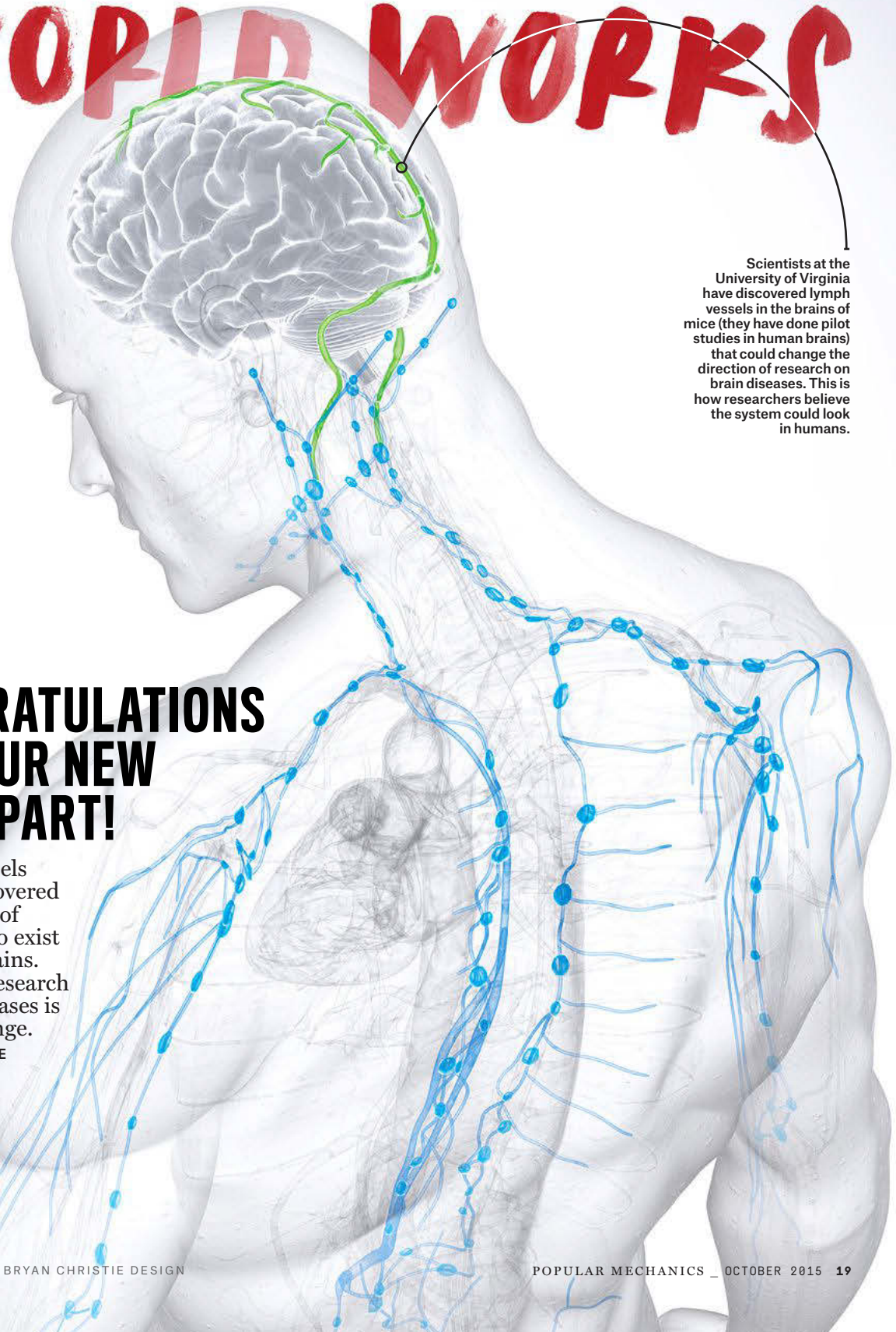
HOW YOUR WORLD WORKS



Scientists at the University of Virginia have discovered lymph vessels in the brains of mice (they have done pilot studies in human brains) that could change the direction of research on brain diseases. This is how researchers believe the system could look in humans.

CONGRATULATIONS ON YOUR NEW BODY PART!

Immune vessels recently discovered in the brains of mice may also exist in human brains. Either way, research on brain diseases is about to change.

BY JACQUELINE DETWILER

ILLUSTRATION BY BRYAN CHRISTIE DESIGN

Four millennia into the study of anatomy, new body parts are discovered at about the rate that comets buzz the earth, often with a similar amount of fanfare. The last one, in 2013, was a knee ligament. Before that, it was a microscopically thin layer of eyeball. This summer Antoine Louveau, Jonathan Kipnis, and their colleagues at the University of Virginia School of Medicine discovered a possible piece of anatomy worth a great deal more excitement: a section of the immune system that reaches into the brain.

The discovery was a viral news story for two days—"Lymphatic Vessels Extend Into Brain!" To many, it was another comet, but to scientists who study an unmapped, last-frontier kind of system like the brain, a discovery like this upends fundamental theories, the same way finding iron-based cells or water on Mars would. Over the past decade researchers had increasingly seen evidence that the brain and the immune systems interact, but no one was sure how. "We were always trying to interpret how the two systems communicated based on the fact that this structure didn't exist," says Louveau. Now that we know it does, researchers who work on every brain disease with a suspected immune component have the opportunity to try something completely new. Here are four scientists who are excited about what that means.

Antoine Louveau (top) is a postdoctoral fellow in the lab of Jonathan Kipnis at the University of Virginia. Louveau found the vessels while trying to confirm that they didn't exist.

FOR MULTIPLE SCLEROSIS

In patients who have multiple sclerosis, an overactive immune response causes T cells to attack myelin, a fatty neuron sheath that speeds impulses through the brain. Some MS drugs, such as natalizumab (brand name Tysabri), work by preventing T cells from passing into the brain through blood vessels, but this can allow nasty infections to spread unchecked. "Maybe there's an approach where we can target these new lymphatic vessels to accomplish the same feat without the side effects," says Bruce Bebo, executive vice president of research at the National MS Society. "That's just one potential example."

FOR AUTISM

In some kids who have autism, getting a fever from the flu or a cold can temporarily improve behavior, attention, even verbal skills. Researchers suspect this may be related to chemical messengers called cytokines, which can communicate to both neurons and immune cells. "For me, knowing that this system exists helps with trying to match what's going on in the body with what's going on in the brain," says Judy Van de Water, an immunologist at the University of California Davis MIND Institute. Measuring cytokines in the lymphatic system of mice in real time could help researchers figure out how the fever effect works.

FOR ALZHEIMER'S DISEASE

"One of the big surprises in the genome studies that have come out over the past five or six years was that there is a whole set of genes that affect Alzheimer's that are expressed in the immune system, not in neurons," says Bruce T. Lamb, staff scientist at the department of neurosciences at the Cleveland Clinic. Scientists believe most of the deficits seen in Alzheimer's patients are related to a misfolded protein called amyloid-beta that isn't cleared properly from the brain. The next step is to determine whether a malfunction in these newly discovered vessels could be responsible.

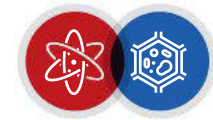
FOR DEPRESSION

Some of the most exciting research on depression concerns the role of the gut microbiome—the contingent of bacterial cells that live in the stomach and intestines. Depressed patients are more likely to have certain bacterial species in their excrement, and feeding mice particular probiotics can reduce behaviors that mimic depression. "There was some beautiful work just published that showed that changes in the gut microbiome can change the structure and function of microglia, which are immune cells in the brain. How can bacteria affect those?" says Kipnis. "We don't know, but we're working with the author of that study to find out."

OTHER BRILLIANT COMBINATIONS IN SCIENCE

Interactions between the immune system and the brain have been intensively studied since only 2008 or 2009, when scientific consensus that the two systems were connected reached critical mass, popularizing the field of neuroimmunology. Here, three other cross-disciplinary sciences that might change the world.

—JAKE CAPPUCCINO



Physics + Biology =

QUANTUM BIOLOGY

Deeper than molecular biology, quantum biology uses computers to model the profoundly weird quantum-mechanical processes behind biological phenomena such as photosynthesis.

Psychology + Genetics =

EPIGENETICS

Once geneticists had mapped the human genome, they could study how the environment changes the way genes are expressed in real life. One crazy finding: Some changes to genes after birth can be passed on to the next generation.

Chemistry + Materials Science =

CHEMOMECHANICS

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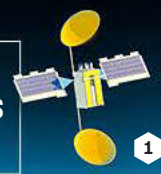

THE COLDEST WAR

Unclaimed and rapidly becoming more valuable, the Arctic Circle has become the center of the latest international arms race.

BY JOE PAPPALARDO

Some 20 percent of the ice in the Arctic is expected to melt by 2050, opening about a million square miles of valuable terrain to shipping, oil drilling, mining, and tourism—all of it located in one of the few places on the planet without an owner. "There are many competing claims, and whoever can enforce the claims will reap the benefits of the resources," says Sim Tack, a military analyst with the global intelligence and advisory firm Stratfor. The high north is also valuable from a military standpoint, and with no treaties prohibiting the deployment of weapons there, nations around the Arctic Circle—including the United States, Norway, Canada, Sweden, and Russia—are sending up equipment and vehicles to develop a presence. "Demonstrating the ability to deploy forces into the Arctic backs territorial claims and boosts the perception of a military deterrent," says Tack. Here's who's building what above latitude 66°32' N.

1 | Satellites

Military satellites in geostationary orbits around the equator can't make contact with Arctic ground terminals because signals are blocked by the curvature of the earth, much the same way a fly buzzing around an apple's center can't see the stem. Now the U.S. Navy is launching a network of satellites, the Mobile User Objective System (MUOS), that has more high-power beams and waveforms that can bend around the earth's curves to reach the poles.

UNITED STATES

2 | Aerial Drones

Low temperatures can cause moisture to freeze on the wings of unmanned aerial vehicles, weighing them down and jamming flight-control surfaces. As a result, both Canada and Russia are testing models that can tolerate minus 30 F temperatures and high winds. Last year Canada tested a drone helicopter during August exercises in the Arctic. The Russians, meanwhile, began field-testing the propeller-driven Orlan-10 this year.

CANADA, RUSSIA

3 | A New Spy Ship

Since the mid-1990s Norway's naval vessel *Marjata* has been conducting surveillance on Russia's Northern Fleet. Now the Norwegian Intelligence Service is buying a new ship, for about $250 million. When operational in 2016, the next *Marjata* (it's keeping the name) will be almost twice as large—at 413 feet long, the size of a large passenger ferry—and ready to cover more ground for longer periods, enabling the Norwegians to watch their Arctic backyard.

NORWAY

4 | Submersible Robots

In May the NATO research vessel *Alliance* cruised off the coast of Norway to test underwater robots that could be used to hunt submarines in the Arctic. Among the equipment tested were gliders powered by wave motion and torpedo-shaped bots that use onboard sonar to listen for signals. Researchers say future versions of the latter could drop strings of disposable sonar sensors, called sonobuoys, to create invisible nets.

NATO

5 | Nuclear-Missile Submarines

The Arctic is important in part because it's the preferred place for U.S. and Russian submarines to launch nuclear missiles in the event of a cataclysmic war. "The shortest distance between NATO countries and Russia is within the Arctic Circle," says Tack. This is why the Pentagon is concerned about Russia moving new Borei-class submarines with water-jet propulsion and long-range sonar into the area over the past year.

RUSSIA

ILLUSTRATION BY SINELAB

Popular Mechanics

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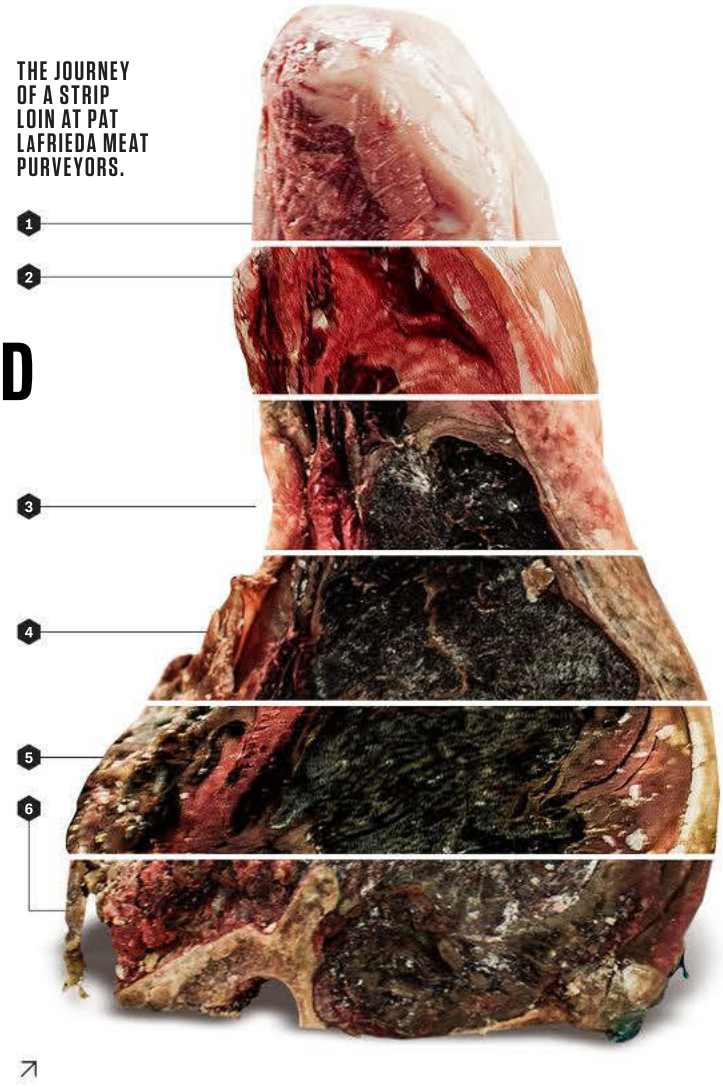
ALL THE GOOD FOODS ARE HALF BAD

Beef, cheese, wine—all flavorful and all aged. Here's why the tastiest old food doesn't make you sick.

BY WYLIE DUFRESNE



1. Original

2. Aged 21 days
Collagen begins breaking down.

3. Aged 30 days
About 15 percent of water weight lost.

4. Aged 40 days
Funkier tasting.

5. Aged 50 days
The white is good mold and salt, similar to that on an aged cheese.

6. Aged 120 days
The true connoisseur's steak.

The first time I tasted rot—as in real, funky, fully formed mold—I was not in any condition to legitimately evaluate it. I had put away one too many drinks and figured I should eat something, so I headed into a dark kitchen, grabbed a slice of bread from the bread box, and chased it down with a glass of milk. Two seconds later I realized something was horribly wrong. I turned on the lights and saw that the bread, like my judgment, was fuzzy.

There's a rather large difference between rotten bread and something that's deliciously and intentionally rotted. The terms that describe the latter include dry-aged, fermented, and ripened, but they all refer to the same thing: creating the unique conditions under which desirable microbes can flourish, transforming a food into something delicious while undesirable microbes die off.

Most kinds of "good rot" are rooted in the practices of preserving food. Take, for example, sauerkraut. At some point somebody figured out that salting a bunch of chopped-up cabbage and leaving it in a barrel creates a mash that tastes great and lasts longer than an old head of cabbage left in the root cellar. He probably didn't know anything about the lactic acid–producing bacteria that lower the pH of the mash, making it safe to eat.

Lactic acid bacteria live on cabbage leaves in the field, but in many cases creating good rot involves introducing a protective mold or bacterial culture to a food and keeping it happy enough to grow. Blue cheeses get stabbed with skewers covered in strains of penicillium mold to create those signature veins and give the cheese its distinctive taste. Camembert's white rind is another type of penicillium that gives the cheese its slightly funky flavor and defends the cheese from dangerous microbes like a shield.

While I eat cheese almost every day, I think the fine art of rotting is at its best when applied to dry-aged beef. Butchers store whole racks of rib steaks in a very cold and slightly humid environment, allowing time for enzymes already inside the meat to slowly start breaking it down, bringing out the potential sweetness and umami hidden within the protein and glycogen. The fat cap—the layer of fat over the meat—reacts with oxygen from the air at a steady pace. While the flesh is transformed, so is the fat that bastes it as it cooks.

Some argue over whether dry-aged beef is texturally better (I believe it is), but everyone agrees that the flavor is superior and significantly more complex than that of unaged beef. Both the flavor and texture are due to the action of microscopic entities similar to the ones that would ruin a neglected rib eye. The difference comes down to the species of microbe you're allowing to grow: An old piece of meat left in your fridge could pick up dangerous microbes from the foods around it the same way butter left open absorbs other flavors. It would end up covered in mold, of course. Just not the kind you'd want to eat.

WYLIE DUFRESNE is a mad scientist and chef at Alder in New York City.

MYSTERIES OF OLD FOOD REVEALED

What are the ideal conditions for aging a steak? Dry aging doesn't actually mean the steak sits around in a sauna. It just means that it loses moisture during the process. Most steaks are dry-aged for 14 to 35 days at 32 to 39 degrees Fahrenheit and a humidity of 80 to 85 percent. During that time, collagen, a tough connective protein, breaks down, making the steak more tender.

Why do we eat aged beef, but not pork or chicken? Part of the reason might just be lack of demand. Aging usually adds an upcharge, and expensive chicken lacks the intrigue of an expensive porterhouse. On the other hand, pork contains less collagen than beef, so the perceived change in tenderness from aging might also be less noticeable.

—LARA SOROKANICH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HOW TO CURE EMAIL

Spending hours on correspondence makes employees inefficient. So a few companies have begun (temporarily) outlawing it. **BY ALEXANDER GEORGE**

Conversation Starters for Smart People

Date of the first email: 1971

Number of emails sent each day: More than 205 billion

Why do email addresses contain the @ symbol? "It's the only preposition on the keyboard." —Ray Tomlinson, email's inventor

Late last summer Mary Pat Knadler, a research fellow at pharmaceutical giant Eli Lilly and Company, received an email that made her concerned that she was going to annoy her colleagues. For ten days she and 179 other employees at her Indianapolis office would not be able to use Outlook between 8 a.m. and 10 a.m. "I work with people around the globe. That's a time when I am very productive," Knadler says. Even through multiple time zones, when she sends an email, she knows the person on the other end will see it as soon as he's available. And vice versa.

If you've worked in an office since roughly 1997 you can understand Knadler's concern. In an age of constant push notifications, every chime feels urgent, to the point that it damages our ability to concentrate. Electronic mail sucks about two and a half hours from a typical employee's workday, and can diminish the restorative effect of time off. This is why companies like IT firm Atos Origin have zero-email policies, and why, when someone at Daimler, the German carmaker, is on vacation, the company server deletes incoming emails from the employee's inbox. Eli Lilly, a company that made nearly $20 billion last year, decided to experiment with a temporary email hiatus, in the hope of easing the burden.

To do this, the company built a program that would intentionally disable Outlook every morning for ten days. The results: Participants sent 90 percent fewer emails during those two hours (a few used their phones to sneak around the ban) and 30 percent fewer emails throughout each day. Using estimates for the average time an employee spends composing an email, and assuming that the time was used for something productive, Eli Lilly analysts estimated a productivity increase of 10 percent. Those figures don't include time spent reading emails, making the results a conservative estimate of the benefits that can come from restriction. "It's liberating to know that most things can wait 24 hours," says Anja Stauber, a director of toxicology who participated in—and enjoyed—the trial. "Waiting can actually make [your response] better."

Knadler's email-free period didn't go quite as smoothly. Some of the other Eli Lilly branches she worked with didn't know about the trial. Though there were no flameouts or missed multimillion-dollar deals, she did receive follow-ups from colleagues who asked why she wasn't responding quickly. "I apologized a lot," she says. Her experience, maybe, is the email problem in miniature—manufactured urgency creating the expectation that immediate responses are both possible and desirable.

Those who are disciplined enough to control email, rather than allowing it to control them, may prefer to leave the medium the way it is. Psychological research, however, indicates that allowing the inbox to continue its bullying will bring the rest of us to the end of the workday feeling as though we'd gotten nothing done. Temporary breaks like Eli Lilly's portend a future in which employers respect human attention as the sole remaining technological limit to productivity—a future in which the only office communiqué likely to cause a panic attack is the fire alarm.

THE ART OF BEING UNAVAILABLE

If your company won't consider an email suspension, you can use apps to reclaim your productivity. Here are three that make the Internet saner.

FREEDOM

Specify a time frame, and this application will block your Internet connection, relenting only if you reboot your computer. It also prevents you from going down Wikipedia rabbit holes. ($10)

RescueTime

It runs in the background, tracking your computer use to help you adjust your habits. Tell it your most time-sucking sites and it'll kick you off after you reach your self-imposed limit. (Free, or $72 per year)

BOOMERANG FOR Outlook

Need to send an email after work but don't want to stress anyone else out? Download this plug-in for Outlook or Gmail and you can schedule it. Start with a whole year's worth of Happy Birthday messages. (Free trial)

PHOTOGRAPH BY BEN GOLDSTEIN

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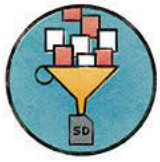


How do manufacturers keep packing more gigabytes of space onto smaller and smaller SD cards?

A **WE HAD AN IDEA** on this one. A hypothesis, as the science-minded might say. Alternatively known as the Tokyo Subway Theory, or the Fat Guy With a Samsonite Construct, we postulated that each card came equipped with a tiny man, a high-tech homunculus, who shoved, jammed, and/or jumped up and down on our data as necessary, forcing it to fit. This, it turns out, was wrong, as phone calls to memory maestros at manufacturers Intel and SanDisk soon established.

The unceasing march toward more digital storage in smaller physical space traces its roots to the inception of the microchip. In 1965 an engineer named Gordon Moore, a future founder of chipmaker Intel, published a paper noting that the number of components that could be shoehorned onto a chip had doubled every year since 1959. He predicted the trend would continue—and indeed it has, for 50 years. Now, here we are, courtesy of what became known as Moore's law, with what amount to really small but very capable containers. SanDisk's new micro SD card, for instance, is about half the size of your thumbnail and can hold 200 gigabytes of data.

How the heck does it do that? It uses something called flash memory, which employs no moving parts. Flash, or solid-state, memory relies upon electrical charges centered over transistors to record the ones and zeros (bits) into which data is translated. Things get a tad complex, but in short the trick to upping the memory is to figure out how to use fewer electrons to make each bit a one or a zero. At the advent of flash memory it took millions of electrons per bit. Today each may require as few as ten or 12. The next frontier is three-dimensional storage—stacking information vertically on a chip like a tiny skyscraper. A tiny skyscraper, we would suggest, of the sort that might be populated by tiny men who jump off tiny balconies onto your data, packing it ever more tightly onto the chip. Patent pending.

What is the loudest natural sound on earth?

The loudest thing we've ever heard was a Kiss concert at Madison Square Garden—rivaled only, perhaps, by the bullhorn-grade shouting required to communicate with us over the ensuing 48 hours of temporary deafness. But there's nothing especially "natural" about pounding out "Love Gun" at sound-pressure levels that would drop a rhino at 400 yards, and Madison Square Garden is kind of its own planet anyway.

The key distinction here is whether you mean what is the loudest natural sound, or what is the loudest sound you could actually hear and live to talk about. A Google search might tell you that the loudest sound ever was the eruption of the Indonesian volcano Krakatoa in 1883. And in some sense, that's true. The explosion that kicked things off was measured at 172 decibels (dB) 100 miles away. To put that in perspective, a chainsaw is about 110 dB, and the pressure on your ears doubles with each 6-dB increase. So figure, at the site, the sound was, let's see here, 172 minus 110 divided by 6 . . . instantly-burst-all-your-blood-vessels-and-kill-you-before-you-even-hear-it loud. At that level (or anything above 194 dB) it doesn't even really count as a sound anymore—it's just a pressure wave.

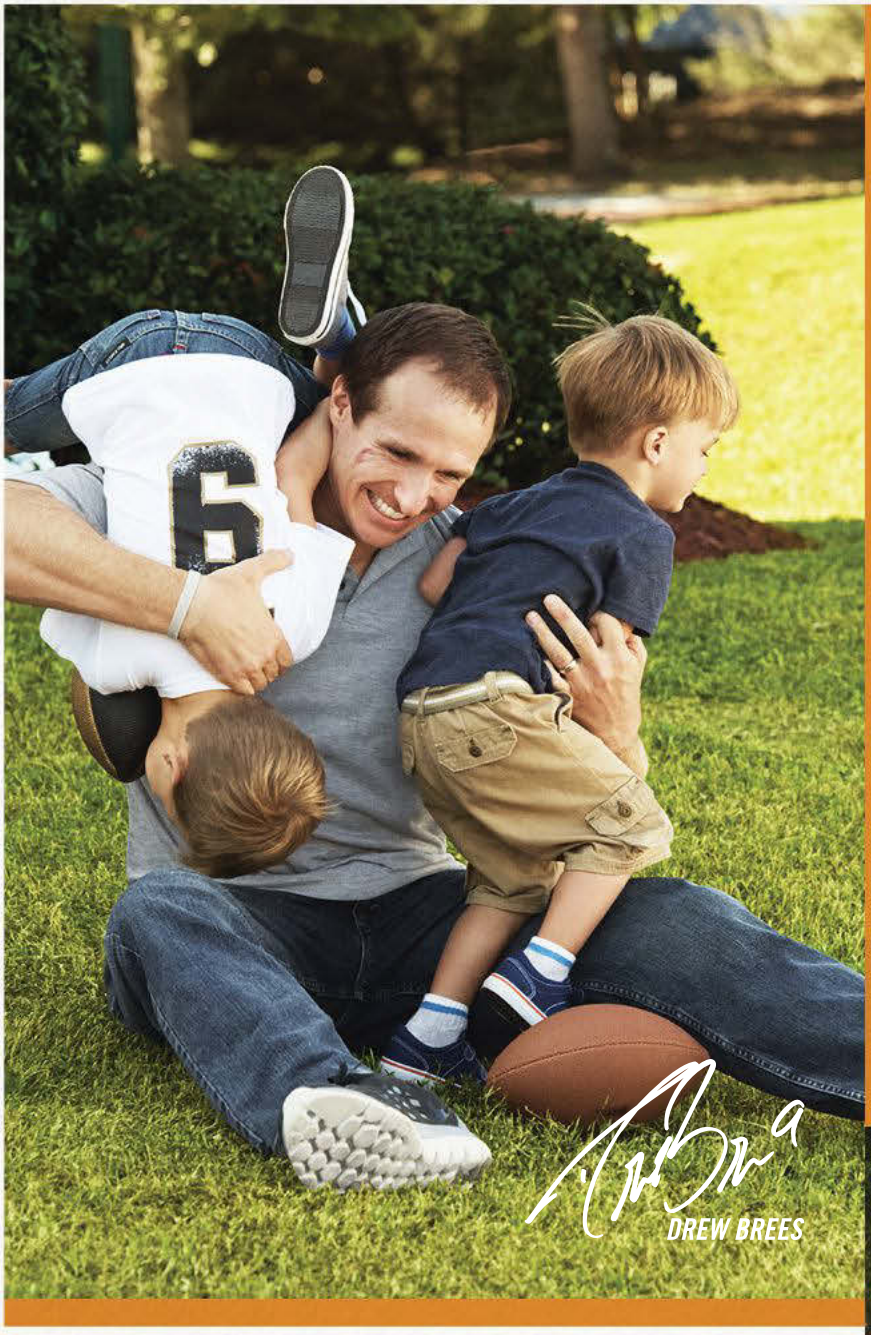
Assuming you're talking about a natural sound that's audible rather than lethal, we turned up a few nominations. Richard Raspet, a physics professor at the University of Mississippi who specializes in outdoor sound propagation, suggests that the crack of a lightning bolt (not thunder) may be Mother Nature's noisiest noise. Michael Epstein, director of the Auditory Modeling and Processing Laboratory at Northeastern University, adds that the call of the blue whale can approach 190 dB. So do your ears a favor—skip the Kiss show, and, whatever you do, avoid scuba diving during thunderstorms, appealing as that may otherwise be.

Who was the Phillips that gave us the Phillips-head screwdriver? Are there others whose designs failed?

You're talking about one Henry F. Phillips, an inventor and engineer from Portland, Oregon, who patented the Phillips screwdriver and the Phillips-head screw in 1936. Before ole Hank worked his hardware magic, handymen were confined to the slot-head screw, and before that, screws with bolts for heads, which date to antiquity.

There's nothing wrong with slot-head screws per se. The issue arose as manufacturing became mechanized in the early 20th century. Turns out that while the average sober person can easily align a screwdriver in a slot-head screw, machines have a hard time handling it. Enter the first attempt at a fix: a screw with a square recess in the head. The brainchild of Canadian inventor P. L. Robertson, the Robertson screw was stifled by a licensing disagreement and never went into widespread production. Next was J. P. Thompson, who in 1933 patented a recessed cruciform screw intended to be self-centering. Thompson couldn't persuade industry of the benefits of his design, so he sold it to Phillips, who refined it, obtained fresh patents, and saw his namesake screw adopted, notably, by General Motors, who used it to build Cadillacs starting in 1937. It was, of course, a very smooth ride from there.

TYPOGRAPHY BY GEMMA O'BRIEN; ICONS BY ADAM LEISENRING



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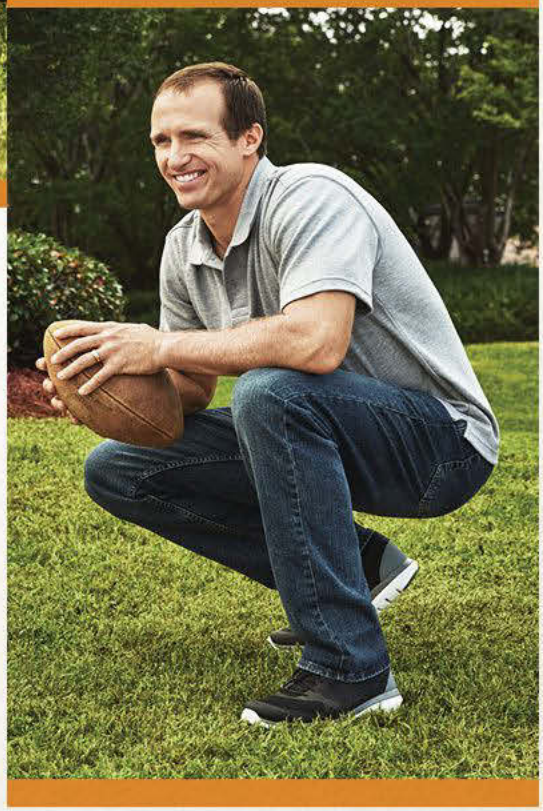

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We all need places to get outside—to explore, exercise, and recharge. But with America's open spaces disappearing at a rate of 6,000 acres each day, we're at risk of losing our most cherished outdoor escapes. Together, we can change that. Join The Trust for Public Land to save the lands we all love—from urban parks to vast wilderness. Since 1972, we've worked with communities to protect more than 3 million acres and create more than 5,000 parks and natural places for people to enjoy. Help to keep this land our land.

Share why nature matters to you: **tpl.org/ourland | #OurLand**

THE TRUST *for* PUBLIC LAND

INSIDE: The best cordless leaf blowers page 38 | Booze worthy of the Pilgrims page 42 | Tile-cutting tricks page 50

SKILLS

THE ART OF FIREWOOD

It can be so much more than chopping and splitting.

BY C.J. CHIVERS

On a crisp December dawn, after a cup of hot coffee and a plate of warm eggs, a winter's weekend routine began. I roused the kids, who groaned and briefly resisted. While waiting for them to dress and find their way downstairs, I stepped out to the chilly shack and checked the tools and safety kit—padded earmuffs, impact-resistant goggles, heavy gloves, scrench, wedges, rope, first-aid box, and a freshly sharpened spare chain. The saw, a 70.7-cc Husqvarna, brimmed with bar oil and fresh 50:1 fuel.

I walked down the gentle slope behind our house. At the small woodlot at the edge of our neighbor's property were three trees that needed to come down. One, a huge locust, had split almost from the ground to 20 feet up. It swayed and creaked in a light breeze. Beside the locust was a thick maple that was succumbing to the unrelenting industry of carpenter ants, which had softened a wide band from about 5 feet above the soil to more than 15 feet overhead. Heart rot had followed the ants' intrusion, leaving much of the trunk as soft as Styrofoam. Without an intervention, this tree was going to meet a violent and unpredictable end. Another ant colony had settled into a second maple nearby. Weakened, that tree leaned precariously over a shed. These were problems that were not going to solve themselves. Our neighbors had invited us to remove the trees and keep whatever firewood we wished.

Soon the kids had joined me, and we set to work on a labor that would last, off and on, into spring: felling, limbing, bucking, and then hand-carrying the wood home, where it would be split

and then stacked for seasoning. We would do it piecemeal, a few hours at a time, working in the effort between their homework and other demands.

We began by clearing a few bits of brush under the first tree, making a safe place to work and an open escape route in case of the unforeseen. We chose the felling direction, and discussed the spots for notch and felling cuts.

The children backed off before the two-stroke engine roared to life. I released the brake. The chain began to spin. A long chore that I would look forward to each weekend had started—harvesting future heat, together, and almost for free.

In an age when many Americans heat with gas, oil, or electricity, the richness and rituals of gathering and seasoning wood for homes risk fading into our past. Those who use wood heat do more than save money, live locally, and keep some of their cash from flowing offshore. They tap into a primal activity, and often enjoy rewards beyond what they might expect.

What can I mean? The varied tasks related to heating a home with firewood can create an intimacy with your surroundings and with your family that is as sustaining as the warmth the wood provides as it burns.

Even the woodpiles themselves become a tangible library of memory. Each section of our stack tells of its source. The once bright yellow splits now slowly dulling to brown came from an old locust that had snapped in a hurricane. The rich gray section with heavy bark has its origins in a leader off a massive, trident-shaped oak that crashed to the ground after a heavy, wet snow. That oak piece—my kids named it the beached whale—had to be hand-split in place and carried uphill, chunk by chunk, to the pickup, excepting what the kids ferried home in a hand-pulled sled.

Firewood comes to us opportunistically. A neighbor will want a tree felled. A storm will blow through and knock down limbs or uproot and topple entire trees. A few trees will have to go to make way for a home addition or access to a new lot. Sometimes it almost seems as if the wood finds us.

Occasionally the wood can carry other meanings. We cut and carted away the white birch rounds from the sprawling grounds of a condo association at the request of a friend who was managing the place. The property had lost trees in a storm, but the contractor hired to clean up the mess had left much of the wood behind. My children and I ended up with the bounty, glad to help, grateful for the fuel. Not long after we split and stacked a few truckloads, our friend was diagnosed with cancer. She passed with startling speed. Every time we bring a sack of birch inside for the stove, we think of her, aware of the emotional power a wood stack can hold.

Two of the five young members of the Chivers clan hard at work.

Under the trees on that cold December day, the work took its shape. We felled the first maple, then the locust, limbed much of them, and started to carry home the rounds, armload by armload. This would take a long time. But we had been lucky not to have a barrage of winter storms, and we knew we should collect and move as much as we could before winter bore down and covered the site in snow, locking the wood in ice.

The next weekend we returned. And then again, until the wood was frozen up tight.

Still, we had plenty to do. Until recently, a weathered stockade fence stood along our southern property line. A previous owner had installed it, and for a few years it had been sagging. Then came Superstorm Sandy in 2012, which neatly snapped a few of the rotting posts at the ground on the way to blowing down several sections of fence.

This led to an epiphany. Why pay the lumber costs for a new fence? Why even replace the fence with a fence? What if, instead of rebuilding a suburban standby, we built a wood-seasoning rack along the property line that would provide the same function—privacy and a windbreak—for a portion of the cost but would be far sturdier, more handsome, and useful too?

HOW TO FORAGE

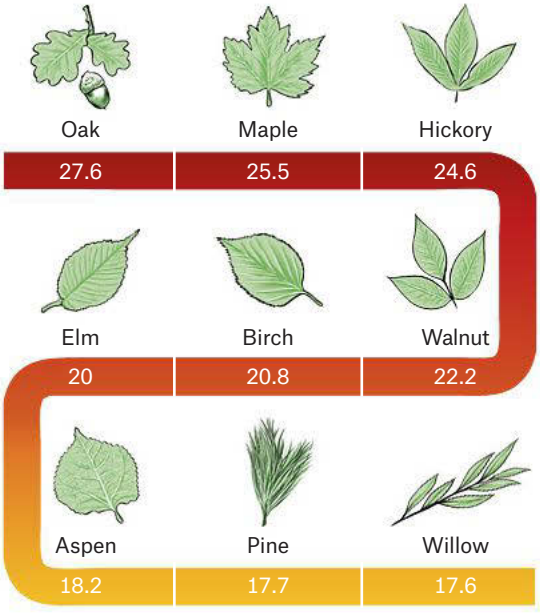
1 Find wood from spruce, aspen, birch, willow, or pine trees for kindling. Although these woods burn quickly, they light easily. (Fires made with them are also easier to extinguish because they don't leave much of a charcoal bed.)

2 Be wary of wood that you find on the ground, as it's more likely to be wet or rotten.

3 Most of your campfire wood should come from low branches. If they snap off easily, they're dead already and will burn well. If they don't snap off easily, leave them alone.

4 For larger, longer-burning pieces of wood, find a nut-bearing tree. Oak, hickory, walnut, and maple are all hardwoods, which means they're denser and have a higher Btu. (See below.)

Dry wood in descending order of Btu in millions per cord



ILLUSTRATIONS BY JOEL KIMMEL

SIGNS YOUR WOOD IS WELL-SEASONED

- ✖ **It doesn't smell like wood.** Most of the woody scent you get is caused by moisture.
- ✖ **It's dull in color.** Seasoned wood should look gray.
- ✖ **It's not heavy.** Water makes up as much as three-quarters of the weight of a green piece of wood.
- ✖ **The ends have cracks.** As the wood dries out, it becomes more brittle.
- ✖ **The bark is missing or comes off easily.** When the moisture goes, the bark usually goes with it.
- ✖ **It sounds hollow when you hit it against something.** (Probably best if that something is another log.)

I was busy with work, but scrounged the hours to remove what remained of the old stockade. Then I paid a carpenter friend to install a basic rack made with paired pressure-treated 4 x 6s as posts and 2 x 6s running low and parallel to the ground, like baseboards.

A crude but eminently sturdy and functional system had taken form. Each section held more than a half cord. With nine sections and a southern exposure, our would-be fence amply stored (and cured) a sizable portion of our annual firewood needs while taking up almost no yard space. And it looked good.

With time, however, flaws in its quick design emerged. First the posts heaved ever so slightly during seasonal freezes and thaws, forcing the racks out of their original parallel arrangement. This not only looked bad but it also changed the way the firewood sat, so much so that one stack between the posts bulged and collapsed in another hard storm.

Restacking is labor lost. So as the last of the seasoned firewood found its way into our pair of woodstoves, and as we found a new source for wood but could not work with it until a thorough thaw, it was time for an upgrade.

Using a level, heavy bar clamps and a come-along for tension, and framing lumber to force the posts back square and true, we straightened the posts, bringing each perpendicular to the ground and parallel to the others. These we locked in place with newly purchased pressure-treated 2 x 6s about 3 feet above the original bottom rack, each resting on a cleat for extra support. In one rack we framed the opening for a small gate.

When winter loosened its grip, we returned to the trees at the edge of the woodlot out back, and finished cleaning them up. Our neighbors lent us their John Deere 52 log splitter, a mini-beast and a gem from the early 1980s that had become slightly balky with age. We commenced the next step: splitting the gathered fuel to size.

In an age when many Americans heat with gas, oil, or electricity, the richness and rituals of gathering and seasoning wood for homes risk fading into our past.

After a few shifts I managed to break the pull cord off the starter. A call to a friend who repairs commercial fishing boats led to a quick session in the yard, during which we removed the starter, rethreaded and tied in the cord, and then cleaned and tuned the carburetor. Soon the machine was purring, its old Briggs & Stratton engine contentedly revived. Over the course of the next few weekends my sons and I converted about ten cords of green wood into splits.

By then spring had warmed the yard. Potatoes were sprouting, and asparagus too. The woodstoves in the house and the shack were clean and silent, idle until fall. The new green firewood was neatly piled about the property, beginning to dry. The chainsaw was cleaned and ready to be put up for the warm season with a fresh tank of high-octane, no-ethanol fuel.

We were done. And we knew the satisfying feeling of being, in one area at least, well-prepared by our own sweat and our own hands. My only regret was that it was over. We'd have to wait another year to resume.

5 WAYS TO IMPROVE YOUR FIREWOOD

With thanks to John Gulland at woodheat.org.

1 Stack wood in a single row, out of the shade, with enough space between the pieces to allow air to pass through. This exposes more wood to sunlight and breeze, which helps dry it out faster.

2 When stacking, use a crisscross pattern to make pillars at each end for stability. They act as bookends for the wood in the center.

3 Before splitting wood on a stump, secure an old tire to the top of the stump. After you split the wood, it will lean against the tire instead of falling to the ground.

4 Cut cords shorter than you think (around 14 inches long), split them smaller than you think (3 to 6 inches wide), and vary the size of the splits. The logs will be easier to carry, and the fire will be easier to build.

5 Check your state's policies on cutting your own firewood. Many states provide licenses for a nominal fee, or even free, that permit people to remove trees from state land.

HOW TO WORK WITH RECLAIMED WOOD

Important lessons on choosing the right piece, avoiding rot, and knowing when to stop sanding. BY GRACE POTTER

I didn't have toys growing up. I had tools. My father was a sign-maker, and his workshop was our toy chest. Although back then all I wanted was a Barbie, I realize that my parents did me a favor: All of the work I did with my dad not only helped me get my first jobs as a contractor (which helped me make enough money to record my first album), it taught me how to be creative.

Even as a full-time musician, I still love to play with wood. Last summer I salvaged a huge wooden door to put on my house, and recently I've been drawing up plans to build a dumbwaiter. The first thing to remember with any reclaimed wood is to make sure the salvage fits the project—never the other way around. You might see a beautiful piece of wood, but if it's too big or not the right shape, you're going to waste a lot of time before you're even able to work with it.

Generally speaking, the best salvage woods are fir, pine, maple, and cedar. Inspect the wood to make sure it isn't rotten. I usually take a small screwdriver and poke around with it to see if it sinks into the wood at all. Sometimes I even take one of those tiny screwdrivers for your glasses. On a fine-grained wood like cherry, if that screwdriver slides in like a pin, the wood is bad. You don't get a spongy reaction from a healthy piece of wood.

When it's time to sand, take off as little as possible, otherwise you ruin the character. And if you decide to seal the wood, be sure to let the poly cure longer than you think it should. Don't let your excitement lead to a fingerprint or dust on your new piece.

OUR EXPERT

After working as a contractor, in 2002 Potter formed Grace Potter and the Nocturnals. The group made four studio albums. Early this summer she opened for both the Rolling Stones and Neil Young, and she released her first major-label solo album, *Midnight*, in August. For tour dates (and albums and some pretty weird T-shirts), go to gracepotter.com.

PHOTOGRAPH BY PHILIP FRIEDMAN

THE BEST BLOWERS

A new generation of battery-powered leaf blowers can handle just about anything.

BY JAMES SCHADEWALD and ROY BERENDSOHN

After testing eight next-generation cordless blowers, it's clear that we've reached a new age of outdoor power equipment. Gas-engine blowers are still the most powerful, but for a wide range of medium-duty jobs (sweeping out the garage, clearing a dryer duct, light leaf cleanup), a battery-powered blower is plenty capable, not to mention faster and easier. We ran four tests, the toughest of which timed how quickly we could clear 6 cubic feet of hay from a 400-square-foot patch of lawn. Okay, the toughest was actually when we used each machine to try to slide a brick over concrete with the blower at a fixed position—unfair, but many managed to do it. Which means they shouldn't have a problem with whatever foliage falls from your oak tree.

BEST OVERALL

WORX WG591 $200

★★★★★

AIR SPEED: 125 mph

Volts: 56
Weight: 8 lb
Hay: 32 sec
Brick? Yes, 15 in.

Likes: Outstanding power-to-weight ratio combined with a highly productive airstream. We used the Worx to clean up what other blowers left behind.
Dislikes: We prefer to control blower output with the trigger, rather than the separate adjuster the Worx uses, which sometimes needed to be switched off before the blower would turn on.

KOBALT 419016 $249

★★★★½

AIR SPEED: 125 mph

Volts: 80
Weight: 9.5 lb
Hay: 39 sec
Brick? Yes, 24 in.
Likes: Three distinct air-speed settings make it easy to adjust the blower to the job. Good power, especially for how quiet it is. Sounds more like a vacuum than a blower.
Dislikes: Blower has a tendency to want to lift, requiring more wrist rotation to keep it pointed toward the ground.

ECHO CBL-58V2AH $269

★★★★☆

AIR SPEED: 120 mph

Volts: 58
Weight: 11.5 lb
Hay: 53 sec
Brick? Yes, 1 in.
Likes: Powerful. Metal-reinforced nozzle is good for times when you have to poke into flower beds or scrape along the ground. Produces a nicely concentrated and productive airstream.
Dislikes: It's not only heavy-duty, it's just plain heavy. That can make it tiring to use.

EGO LB4801 $236

★★★★☆

AIR SPEED: 92 mph

Volts: 56
Weight: 8 lb
Hay: 42 sec
Brick? Yes, 3 in.
Likes: A beast of a sweeper with good power-to-weight ratio. Its airstream is broadly focused, which makes it good for working large areas. A pivoting thumb latch lets you quickly toggle between low and high settings.
Dislikes: The high setting quickly runs down the battery.

BLACK & DECKER LSWV36 $150

★★★☆☆

AIR SPEED: 120 mph

Volts: 40
Weight: 5 lb
Hay: 4 min 8 sec
Brick? No
Likes: Good for light-duty sweeping of hard surfaces, especially in tight spots, owing to its light weight. The only blower that comes with a handy vacuum attachment.
Dislikes: Uses an on/off switch and a roller switch to adjust air output. We prefer a simple trigger-adjusted speed output.

ONE-WORD REVIEWS

★★★★☆
DEWALT DCBL790H1 $370
'Spensive.

★★★★☆
RYOBI RY40402 $250
Balanced.

★★★☆☆
CRAFTSMAN 98021 $150
Prettygood.

▶ For more words on these blowers, go to **popularmechanics.com/leaf-blowers**.

50% EASIER TO LIFT LINERS

The vented BRUTE® container makes backbreaking work easy with innovations you (and your back) will appreciate.

BUILT IN VENTING CHANNELS

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DISASSEMBLY REPORT:

PITCHING MACHINE

MODEL: MASTER PITCHING MACHINE MP-6

PRODUCED: KANSAS CITY, MISSOURI

TIME TO DISASSEMBLE: 5 HOURS, 34 MINUTES

NUMBER OF PARTS: **644**

NOTES: In the early 1950s Paul Giovagnoli owned two driving ranges in eastern Kansas, and thought batting cages might be a good addition. When he had trouble tracking down the company that made them, Giovagnoli decided to build his own. In his apartment. The homegrown construction project got him evicted, but it was the beginning of Master Pitching Machine, which became the company his children run today. While other machines use spinning wheels to shoot balls through the strike zone, the arm action of Master Pitching's "Iron Mike" pitching machines approximates a human pitching motion, which makes for better batting practice.

PITCHING MECHANICS

Like a human pitcher, the Iron Mike has a shoulder, arm, hand, and finger. Unlike a human pitcher, it gets its energy from a **⅓-hp AC motor (12)** and a heavy-duty **torsion spring (18).** The motor connects to the shoulder—technically called the **pitching-arm hub (7)**—via a series of belts, pulleys, sprockets, and a drive chain. As the **main sprocket (11)** turns, its **sprocket drive bushing (10)** pushes on the shoulder. This rotates the **arm (8)** and pulls on the **power cable (16),** a wire rope that connects the shoulder to the spring. The spring coils tighter and tighter with the continued rotation of the sprocket until the arm snaps forward, like a mousetrap springing shut.

LOADING

The MP-6 comes with a **hopper (3)** that holds 600 baseballs. Balls drop into the **ball track (2)** through a hole in the bottom. An adjustable **agitator (4)** spins around the hole to maintain a steady flow. The ball track funnels the balls down to the hand, where a **ball stop (14)** ensures that only one loads at a time.

THROWING STRIKES

Getting the ball through the strike zone is mainly about holding it properly. The angle between the **hand (5)** and the arm is the biggest factor in determining the height of the pitch. Cup the machine's hand in toward the arm and the pitch comes in lower. Pull it back and the pitch comes in higher. If the **finger (9)** isn't positioned properly, the ball will wobble as it is lifted and pitches won't be consistent. The ball travels a long way to get to home plate, so a hand adjustment as small as ⅛ inch can change the height of the pitch by 4 feet. A crank of the **height-adjusting handle (13)** raises or lowers the **spring-broom unit (15),** which alters the release point of the pitch.

OFF-SPEED PITCHES

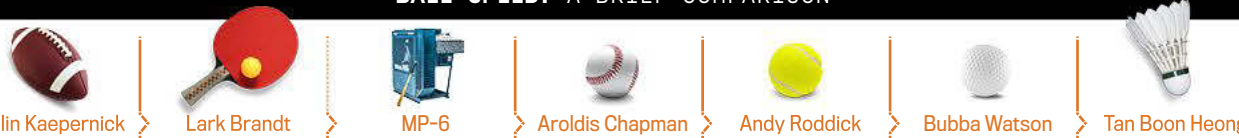
The Iron Mike's pitches top out at around 85 mph but can go as low as 30, depending on the amount of tension on the spring. Connecting the power cable to the shoulder's nearer or farther hole puts the machine in high-speed mode or low-speed mode, respectively, by adjusting tautness. The **spring-tension plate (19)** bolts the spring to the body of the machine. Its four different holes modify the spring's position so it has more tension before the power cable even begins to pull. Once those adjustments are made, the **speed-adjusting handle (17)** slightly coils or uncoils the spring for fine tuning.

AVOIDING BEAN BALLS

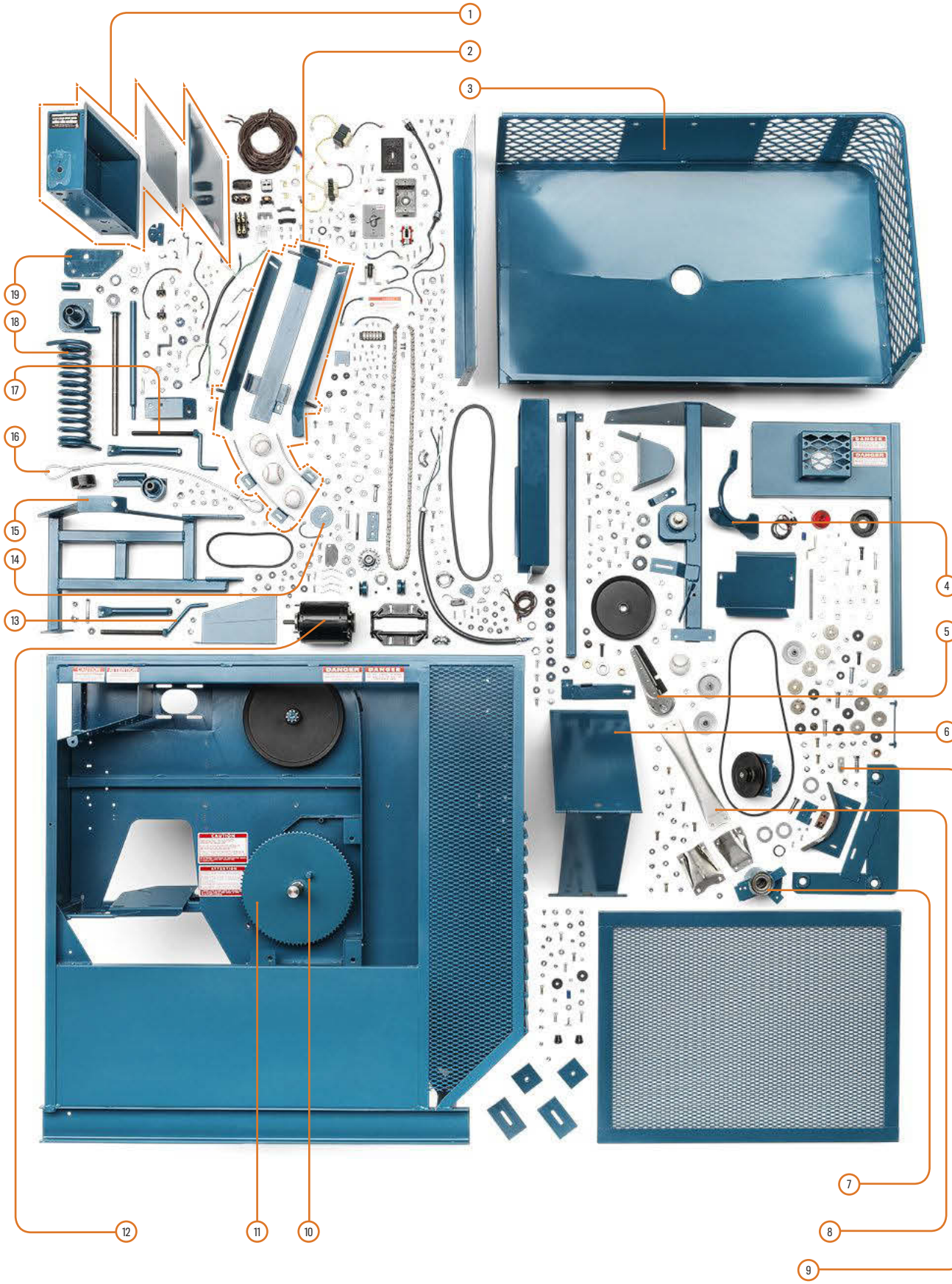
To prevent surprise pitches when the machine is powered up, the **control-box (1)** circuitry turns the machine off only after the arm has reached a position with low tension on the spring. If you're really concerned, you can also add a **locking safety cover (6)** that blocks the opening where pitches leave the machine.

—KEVIN DUPZYK

BALL SPEED: A BRIEF COMPARISON



VIDEO! Watch Iron Mike go from intricate mechanical device to a 644-piece pile of springs, sprockets, and a baseball or two at popularmechanics.com/pitchingmachine.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DIY DRINKING

Liqueurs might conjure images of pinkie-raising bourgeoisie, but they are in fact rustic, agricultural creations, with centuries of everyman history.

BY FRANCINE MAROUKIAN

Ask any Italian-American from Bensonhurst, Brooklyn, to Pittsburgh about his grandpop's homemade liqueurs, and you'll likely get a wide grin. Despite their fancy name, these libations are surprisingly easy to make, and remain a culinary staple for many European immigrants with backyard gardens. But lately, across the country liqueurs are moving beyond ethnic enclaves and into the mainstream.

Unlike the big strokes of craft spirits distilled from limited ingredients, liqueurs are incredibly nuanced, expressing the vast diversity of the plant world: fruits, flowers, barks, herbs, spices, seeds, roots, and nuts. Syrupy and intense, they are designed for sipping, not shooting. With vivid colors and heady aromas, liqueurs can be throwbacks to medieval magical potions made from elaborate secret recipes: Chartreuse, an 18th-century French liqueur called the elixir of long life, is composed of 130 herbs, plants, and flowers. Yet other recipes require just a base spirit and a few simple ingredients for flavoring.

From the Latin *liquefacere,* "to dissolve," liqueurs typically require four components: some sort of distilled alcoholic spirits, raw botanical materials for flavoring, sugar (legally not less than 2 percent by weight), and water. These ingredients are then combined through either maceration, infusion, percolation, or distillation. Once the flavors marry, the liqueur is filtered.

Customarily, Americans drink differently from Europeans because they eat differently, spending less time at the table. In Italy, where leisurely meals are the norm, so are liqueurs, known as *digestivi*. Often characterized as bitter, they are believed to have stomach-settling powers, allowing people to linger at the table while the liqueur does its work. But limoncello, a common Italian liqueur typically served ice cold, is an increasingly popular offering in America's DIY botanical bartending movement. This is a testament to the nation's evolving palate as it moves away from the past decade's farm-centric cooking and returns to its historical immigrant-influenced cuisine.

Old-world civility is perhaps the most appealing quality of liqueurs. Serving one as part of a meal adds an extra dimension of camaraderie. Just pair familiar food flavors with a liqueur that seems to make sense—like, say, apple pie served with a mildly sweet and spicy ginger liqueur—and the end result will be doubly restorative: better conversation and better digestion.

FOR YOUR CONSIDERATION ↓

DON CICCIO & FIGLI *Concerto*
Washington, D.C.
A complex interaction of 15 herbs and spices, barley coffee, and espresso, Concerto is a traditional liqueur from Italy's Amalfi Coast.

BLOOMERY PLANTATION DISTILLERY *Black Walnut*
Charles Town, W. Va.
Bloomery prepares its products by hand on its farm in West Virginia. Its spicy Black Walnut uses nuts from the property.

MAKE YOUR OWN LIQUEUR

Not all liqueurs require a wheelbarrow full of ingredients. Try making this basic pear liqueur using a recipe from Andrew Schloss, author of *Homemade Liqueurs and Infused Spirits*.

❶ Chop 3 pounds pears (about 6). Leave skin on for a more complex flavor, or remove for a less bitter taste.
❷ Combine pears with a fifth of vodka in a sealable glass container. (If using another fruit, fill half the container with vodka first, then add fruit to fill. Avoid low-acid fruits like bananas, which discolor in alcohol.)
❸ For an even more nuanced beverage, add other ingredients such as vanilla, ginger, cinnamon, or chocolate. The more concentrated the flavor of each ingredient, the less you'll need. For example, 1 split vanilla bean, 2 cinnamon sticks, or 2 or 3 slices of peeled ginger would work here.
❹ Stir, then let sit in either a cool or room-temperature environment for approximately seven days, smelling occasionally for readiness.
❺ When mixture smells like fresh pears, use a fine-mesh strainer or damp cheesecloth to remove fruit and other flavor enhancers.
❻ Stir in ¾ cup simple syrup (equal parts sugar and water, boiled until sugar has dissolved).
❼ Store in an airtight container. The liqueur should last for several years.

PHOTOGRAPH BY BEN GOLDSTEIN

The SUN Runs My Oven

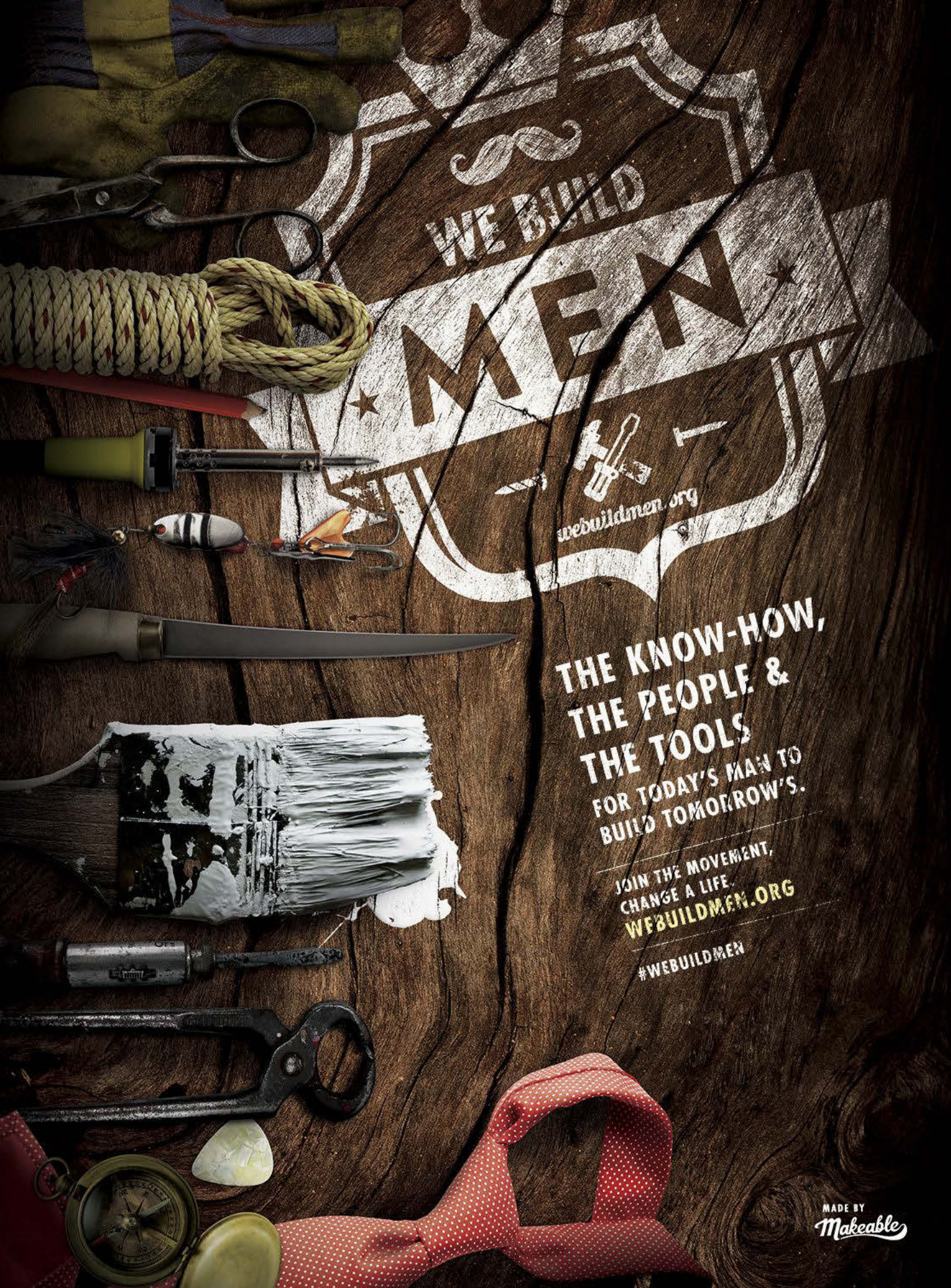
Save the planet without leaving the house.

RENEWABLE
IT'S DOABLE

Going solar at home helps reduce pollution and carbon emissions in your city and around the world. And it's easier and more affordable to do than ever before—that's why every four minutes another American household or business goes solar. Find out how you can be next.

WWF

worldwildlife.org/solar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Popular Mechanics + FALKEN TIRE

TOP SHOP 2015

REINVENTING ADVENTURE

FROM THE SHOP TO THE TOP

Popular Mechanics and its partners transformed an ordinary pickup into the ultimate off-roader for a wild ride up Big Bear. From the tires to the tent (built right into the bed!), this truck takes heart-pounding—and ear-popping—action to all-new heights.

THE BUILD

THE **ULTIMATE ADVENTURE** VEHICLE

Popular Mechanics teamed up with the gear gurus at Galpin Auto Sports (G.A.S.) to turn an everyday truck into an unstoppable off-roader. Outfitted with Falken Tire's next-generation Wildpeak AT3W models, this all-terrain terror is ready to tackle anything the outdoors throws at it. G.A.S. customization experts J.D. Hendrickson and Jordan Mann led the build, and brought the ultimate adventure vehicle to life.

THE FIRST LINE OF DEFENSE

Heavy-duty off-road bumpers don't just look tough. They protect your rear end (and the front one, too) from rough terrain, and let you tow or winch your way out of—or into—all kinds of trouble. **"Heavy-duty off-road bumpers are built to protect against the roughest terrain, and create a rugged look. We made sure to maintain factory features like back-up sensors, too."** — **Jordan Mann**

TRUE WORK OF ART

Vibrant red and stark white combine to create an iconic, search-and-rescue-inspired look that make this truck stand out in a big, bold way. **"Dupli-Color Paint Shop Finish System gives us a smooth, professional finish that's tough enough to resist wear and tear."**
— J.D. Hendrickson

WHERE THE RUBBER MEETS... WHATEVER

Falken Tire's 35" all-terrain Wildpeak AT3W tires are the centerpiece of the off-road experience. They're engineered to better handle mud, dirt, rocks, rain—anything in their way—and get you to the top. **"With tires like these you can basically go anywhere, from the highway to the trails."**
— J.D. Hendrickson

A HANDS-ON EXPERIENCE

The G.A.S. crew used Mechanix Wear gloves throughout the build. The M-Pact® gloves are a favorite among pro mechanics. **"What I love about Mechanix Wear is that it doesn't matter if we're assembling, fabricating, or wrenching on a build, Mechanix Wear has a glove to handle every job."**
— J.D. Hendrickson

FALKEN WILDPEAK AT3W TIRES

VARIABLE SHOULDER BLOCK DESIGN reduces tire noise while maintaining a rugged look.

OUTER APEX BEAD coupled with Dimple Bead Sidewall Construction offers superior durability.

SEGMENTED TREAD BLOCKS provide multi-directional grooves, which gives exceptional traction during all terrain and winter conditions.

SQUARE SHOULDER PROFILE features a dominant stance and exceptional snow and mud traction.

WIDE OUTSIDE SHOULDER GROOVES effectively disperse water and debris in all weather conditions for both on-road and off-road.

A PERFECT TEN(T)

This is a special kind of showstopper. The built-in tent is housed on a custom ladder rack elevated in the truck bed for a totally unique take on camping. **"It's a one-person operation, so you can set it up by yourself. With the ladder extension, you can pull and unravel the tent, and even unzip a room downstairs."**

— Jordan Mann

"The goal was to build an unstoppable off-road vehicle. To be able to get in, go wherever you want, and do whatever you want—no matter where the road takes you."

— J.D. Hendrickson, Galpin Auto Sports

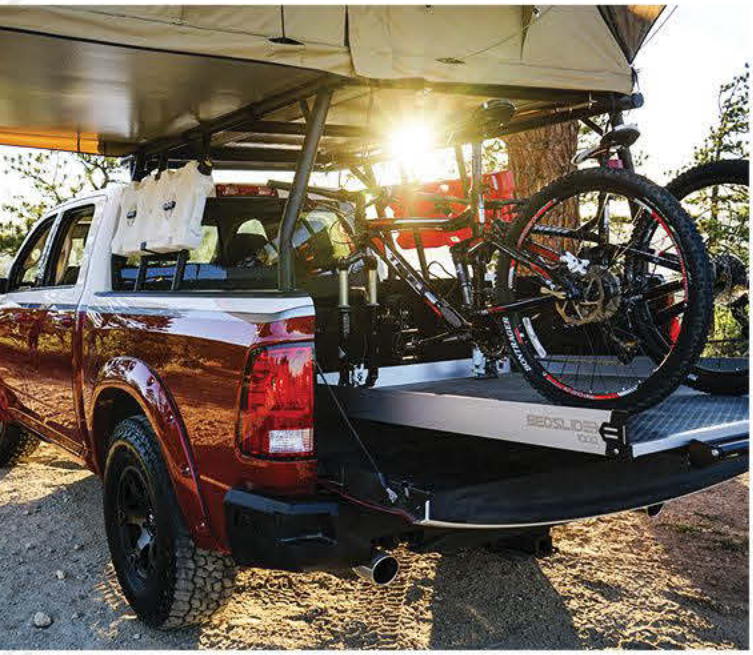
THE DRIVE

DARE TO FIND **ADVENTURE**

THE ASCENT

The 11-hour expedition started in Los Angeles, and ended about 6,750 feet above sea level, with a stunning sunset at Big Bear Lake. Along the way, the wild San Bernardino forest and mountain trails put the truck—and its tires—to the test. Spoiler alert: both came out on top. Literally.

Through it all, Falken's 35" all-terrain Wildpeak tires handled rough roads, rocks, fallen trees, mud, dirt, ditches, and more. With unparalleled traction, control, and stability, these rugged off-roaders are designed to conquer even the mightiest of mountains. And thanks to Dupli-Color's Paint Shop Finish System, the truck has a bold look that stands out whether you're on the highway, or driving high above the clouds.

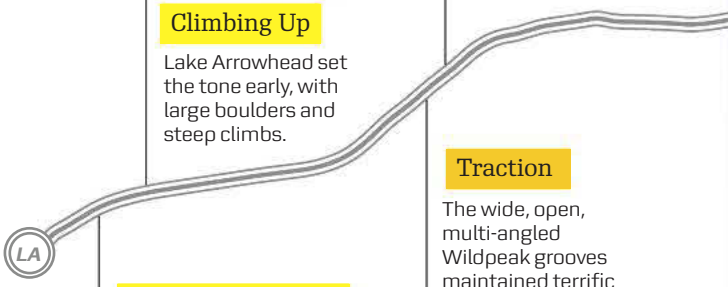


The Elements

Running Springs changed things up with wet, muddy pockets and patches.

Climbing Up

Lake Arrowhead set the tone early, with large boulders and steep climbs.



Traction

The wide, open, multi-angled Wildpeak grooves maintained terrific non-slip traction.

Off-Road Handling

The Wildpeak biting edges gripped the grit, pushing onward and upward.

The ultimate off-roader is powered by Shell V-Power NiTRO+ premium gasoline, for top-of-the-line engine protection from gunk, corrosion, and wear.

"WE MOUNTED 4-GALLON WATER AND GAS TANKS RIGHT THERE ON THE RACK FOR EASY ACCESS, IN CASE YOU NEED A LITTLE EXTRA WHEN YOU'RE OUT THERE."

— Jordan Mann

OUTDOOR SURVIVAL TIPS

01 Water's a priority, so find (and filter) it fast. Flowing water is best, but standing water can be purified by boiling it or leaving a clear water bottle in the sun for a full day.

02 Bring a flint and steel set and light dry twigs, leaves and grass under larger pieces of wood to start a fire. Matches get wet easily, and lighters run out of fluid, but flint and steel always create a spark.

03 To prevent a fire from spreading, use a flat area, ideally dug a few inches into the ground, at least 10 feet away from tents, trees, overhanging boughs, roots, and other flammable items.

04 Time how long it takes to get to your destination, and allow for that long coming back. Check the time of sunset, so you don't have to travel in the dark.

05 No compass? No problem. Point the hour hand of an analog watch at the sun, and picture an imaginary line halfway between that and the 12. That's south. (As long as you're in the Northern Hemisphere.)

Top View

Big Bear Lake's charred forests and steep, narrow trails led to breathtaking scenery.

Smooth Ride

Wildpeak's shoulder block design made for an ultra-smooth, quiet ride to the top.

Top of Big Bear Mountain at sunset

Popular Mechanics' senior home editor solves your most pressing problems.

BY ROY BERENDSOHN

Call 212-649-2828 and leave a message with your home or yard question. You could be featured on a new Popular Mechanics podcast. Questions can also be emailed to askroy@popularmechanics.com.

Q My inexpensive score-and-snap tile cutter doesn't always make a clean cut. Sometimes the cut edge is a little rough, which shows after the tile is grouted. Any advice? *KATE N., CHICAGO*

A Cut-and-snap tools (like the one pictured) work best on smooth, vitreous (porcelain-coated) wall and floor tiles. For nonvitreous and textured tiles, however, you're better off using a wet saw.

Assuming you are cutting vitreous tiles, you should do the following: Hold the tile firmly against the tool's base and make one firm score line, not multiple passes. If the tile slips while scoring or while snapping it, you'll get a ragged break. Use a carbide-grit tile file—which, if you don't own, you should—to clean up minor imperfections on a cut edge. In a pinch you can even rub the cut edge of a scrap piece of tile against the cut edge you just made. Wear gloves while you're doing this, because the tile's cut edge is very sharp. Other causes of bad breaks are a dull cutting wheel and a film of dust or grit on the tile surface that prevents the cutting wheel from scoring a clean line.

If you have a lot of tile work to do, treat yourself to a professional-duty model. Kraft Tool's Superior Tile Cutter is a great American-made cutter. A small version of this classic costs about $40, which may be twice what you paid for the score-and-snap, but it's easily twice the tool.

Q I scrubbed off the oil stains on my asphalt driveway with dish soap, but they came back. Is there any way to permanently remove them?
BURT R., BRICK, NEW JERSEY

A You need a more chemically aggressive concentrated cleaner. Use a stiff brush to scrub in Quikrete Concrete & Asphalt Cleaner or Oil Eater Cleaner & Degreaser. Maybe just as important: Follow the cleaning with an acrylic sealer that prevents bleed-through, such as Latex-ite Oil Spot Primer, and then seal the driveway.

Q The concrete sidewalks at the front, rear, and sides of our house all appear to have moved away from the foundation, leaving a gap with the house. What happened?
NORMAN F., INDIANAPOLIS

A That gap occurs when the asphalt-impregnated isolation strip that separates the concrete from the house deteriorates (this normally takes ten to 15 years). Fill the gap by installing a small foam backer rod (it looks like a dowel made out of plastic cellular foam) and applying a bead of polyurethane self-leveling sealant over it. To ensure that this is a long-lasting repair, the layer of sealant should be twice as wide as it is deep. In most cases the gap is about ½ inch wide, so place the foam backer just a bit more than ¼ inch below the surface of the concrete, and apply the sealant so that it's almost even with the top of the concrete.

Q I'm having a terrible time undercutting my doorjambs to install laminate floor. How can I get a cleaner cut?
JOSH E., MILFORD, DELAWARE

A Contractors make short work of this job with an oscillating multitool, which ranges in price from $75 to $200. To use one, first hold a piece of flooring supported on its underlayment against the doorjamb and trim. Rest the tool's blade level with the piece, turn the saw on, and bring the blade in contact with the wood. Don't force the saw through the cut. Just let it work. As you maneuver around the opening, the tool's oscillating motion quickly and cleanly severs the jamb and door trim. Alternatively, an undercut saw is much less expensive—about $20. It's more work, but the same rule applies. Use light pressure, and let the saw's teeth do the cutting. Whatever method you use, brush away debris before sliding the laminate flooring under the door to ensure that it makes a nice, tight fit.

Roy knows, but do you? If you think you do—or even if you just have a creative guess that people of good taste might find amusing—email it to askroy@popularmechanics.com, or tweet us at @popmechhome. One hint: It has nothing to do with orthodontia.

TILE CUTTER: PHOTOGRAPH BY JAMES WORRELL

WELCOME HOME THE BRAVE

Contact us at: findwwp.org

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YOUR ADVENTURE AWAITS

TOUGH TRUCK TIRES

WILDPEAK Tough Truck Tires take you everywhere a new experience awaits, with confidence and comfort.

FALKEN TIRE
ON THE PULSE

CARS

STATS

WEIGHT:
2,332 lb

ENGINE:
- 2.0-liter four-cylinder

POWER:
- 155 hp
- 148 lb-ft torque

TRANSMISSION:
- Six-speed manual

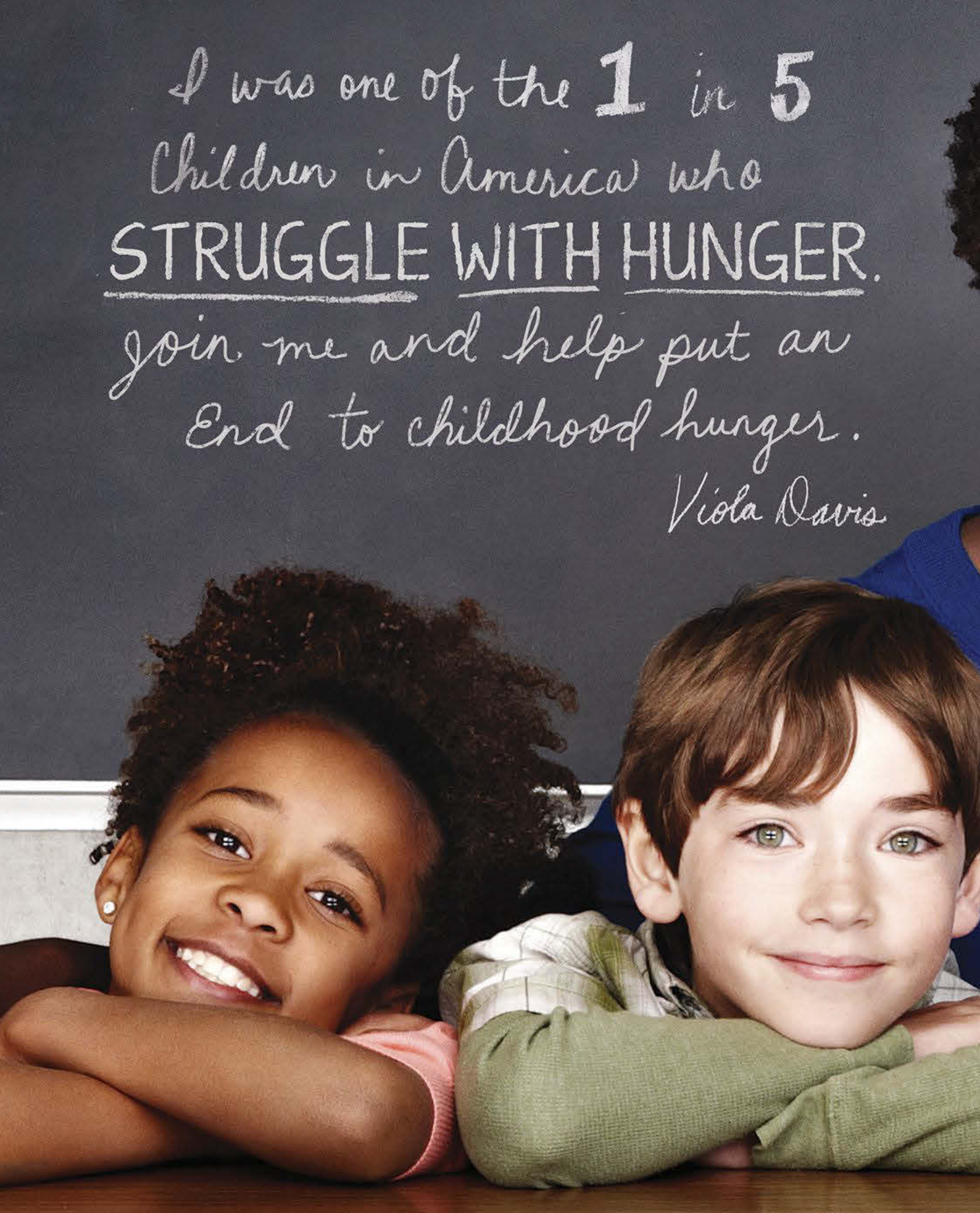
BASE PRICE:
- $25,735

HEY, LOOK, IT'S THE NEW MIATA!

And it finally looks as good as it drives.

The Mazda MX-5 Miata is a misunderstood car. To purists and gearheads, it's the ultimate affordable sports car, a lightweight tub of fun, the rare track car that won't maul your wallet every time you need brake pads. Car people not only respect the Miata, they revere it. That view makes sense. But the rest of the world thinks that Miatas are a little bit goofy—if Hollywood wants to tell us that a character is clueless, it brings in the Miata. Remember the Chris Kattan bomb, *Corky Romano*? Corky drove a Miata. (License plate: CORKSTR.) Mazda got so bummed out about the Miata's image that it once tried to get everyone to stop saying Miata and just call the car MX-5. It didn't work.

UP AHEAD **A Miata for the apocalypse** page 57 ▸ **Gear you need** page 58 ▸ **Reviews** page 60



The *Hunger Is* campaign is a collaboration between The Safeway Foundation and the Entertainment Industry Foundation to raise awareness and improve the health of hungry children.

The Safeway Foundation and the Entertainment Industry Foundation are 501(c)(3) tax-exempt organizations. Photo by: Nigel Parry

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The right team can take a business to the next level.

The experience veterans gain in the military makes them ideal employees in the civilan workforce. Resume Engine translates military experience, training, and honors into relatable job qualifications and allows recruiters to search for veteran candidates at no cost. Veterans can use this free tool to create and share a strong resume with employers nationwide.

Start searching for your next team member today.

ResumeEngine.org

HIRING OUR HEROES
U.S. CHAMBER OF COMMERCE FOUNDATION

TOYOTA
Let's Go Places

So although Mazda finessed the new 2016 Miata with deeply impressive engineering—less weight, snappier engine response, the best manual convertible top ever designed—perhaps the most important thing it did was make it look meaner. This car is not cute or lovable or goofy in any way. With its creased fenders and sharply defined lights, the Miata reads as a shrunken Jaguar F-Type. This is a car that will attract buyers who aren't already part of the devoted fold, while at the same time appeasing loyalists by amplifying the simple pleasures of driving.

The Miata is the kind of machine that tempts you to detour an hour out of your way to hit the Tail of the Dragon, that diabolical scribble of pavement laced across the Tennessee–North Carolina border. Which is exactly what I did. With 318 curves in 11 miles, the Dragon never uncoils enough to let you build up much speed. Here, it's all about reflexes, a car's ability to flow from one apex to another on a road so kinked that your front and rear axles are sometimes dealing with different corners. This is Miata turf, a place that rewards nuance over brute strength.

From top: Ample (and intentional) body roll amps up drama; steering wheel and pedals are directly in front of the driver, not offset; taillights are very F-Type-ish.

Mazda squeezed about 150 pounds out of the new car, no mean feat when the old one didn't weigh that much to begin with. You can examine almost any detail of the car and see where Mazda excised mass. Consider the seats: Mazda uses webbing, like in an Aeron chair, in lieu of weighty foam. It also ditched a height-adjustment mechanism by mounting the seats on angled rails, so the seat rises as you approach the wheel. It all works beautifully. "The whole car is built around the driving position," says Miata lead engineer Dave Coleman. "Driving enjoyment is the fundamental purpose of this car, so we moved things millimeter by millimeter, moving the driver toward the center." There is certainly no wasted space. You can raise a knuckle off the steering wheel and tap the windshield.

Running the Dragon from the Tennessee side means that you're mostly climbing uphill, a situation that the prior Miata would've tolerated rather than embraced. While this one is down on peak power—155 horsepower versus the old car's 167—the new 2.0-liter engine makes more power at anything less than 6,000 rpm. Which is where you're running most of the time. The car feels eager, energized. It's not a Honda S2000, but no longer is the engine just that thing up front that makes the car go so you can enjoy the chassis. The four-cylinder sings, and it's loud, and there's no overdrive gear in the six-speed manual transmission. You may as well take the Dragon rather than the highway.

And on the Dragon, you'll heel over in every corner, body roll being one way that the Miata imparts a sensation of speed. You'll hit the redline in first and second gear but hardly ever get too deep into third. The steering wheel tells you the texture of the road, and whether your left-front tire is on the marbled pavement in your lane or straying onto the smooth paint of the centerline. Mundane family cars and SUVs and plodding Harleys pull out of the way when they see the Mazda's hungry snarl in the rearview mirror.

Respect. It's what the Miata deserved all along.

BEWARE

THE ELIMINATOR

Down in Auburn, Alabama, salvage dealer Alan Branch is using old and new stock Miata parts and a bit of imagination to build track-ready racers called Eliminators. Even better: Later this year he'll start selling $5,000 DIY kits to convert your own old Miata into an Eliminator through his website SalvageWon.com. Consider this a public-service announcement.

FOUR EASY AUTO UPGRADES

Sometimes your car is only a gadget away from greatness (or running). Here are four tempting products I've recently tested on my 1993 diesel Bronco and a 2015 Lexus IS 250.

1 PEAK 3.5-INCH WIRELESS BACKUP CAMERA

$100

CLAIM: You can retrofit a backup camera to nearly any vehicle in just a few minutes.
VERDICT: True, inasmuch as "a few minutes" means 88 minutes.

▸ Peak: Come for the antifreeze, stay for the backup cameras! We're not sure why Peak got into the camera business, but its 3.5-inch wireless backup camera is a pretty solid effort. The "wireless" part is a minor misnomer—the video monitor doesn't need a signal cable, but you've still got to hardwire the camera into your car's reverse lights. That means getting behind the taillights, stripping insulation (or using the supplied wire taps), and routing the wires from the license-plate bracket into the car, which might require drilling a hole. I snuck the signal wire in under my Bronco's tailgate, saving some time. While the process wasn't quite plug-and-play, the camera works great.

2 WEEGO JS12 HEAVY DUTY JUMP STARTER

$130

CLAIM: Carry this little brick in your car and you'll never need jumper cables again.
VERDICT: We'll buy that. No, literally. We're gonna buy this thing.

▸ The JS12 is Weego's midsize power pack, housing a lithium-ion battery that's only a little bigger than those useless scraps of baguette they give you with your lunch at Panera. Weego says the JS12 will start gas engines up to 6.4 liters, or diesels up to 3.2 liters. Since the Bronco is 7.3 liters of rolling compression-ignition thunder, we had to recruit the 2.5-liter Lexus as our dead-battery cadaver. Paddles! Clear! Seconds after connecting the Weego's stubby jumper cables, the Lexus fired right up. The pack also has cables to charge laptops and phones, and a built-in flashlight. Weego sent me this one to test, but I'm sending back my credit card number.

3 A/C PRO AIR-CONDITIONING RECHARGE KIT

$45

CLAIM: If your car's a/c feels like the hot breath of the guy next to you in seat 34B, this'll fix it.
VERDICT: It depends! But it's certainly worth a shot.

▸ On Craigslist the phrase "needs an a/c recharge" is universally acknowledged to mean "a/c compressor was stolen by scrap thieves during the Reagan administration." So I wasn't expecting much when I hooked the can of A/C Pro refrigerant up to the Bronco's low-side charge port. With the engine running and the a/c set to max, the pressure gauge on the bottle spiked into the red. But that could mean either that your system is full of refrigerant or has none at all, depending on whether the compressor clutch is engaged. Since the compressor wasn't spinning, I kept pumping. Slowly, intermittently, the compressor began to engage. Two cans of refrigerant later, the Bronco was blowing ice-cold air for the first time since I'd owned it. Hallelujah, it needed a recharge!

4 REESE TOW-POWER PORTABLE ELECTRIC WINCH

$70

CLAIM: With 2,000 pounds of straight pulling power, you can pull a car weighing up to 6,000 pounds.
VERDICT: When you've got a winch, everything looks like a stump.

▸ I bought this sucker at Tractor Supply Company on impulse. Sooner or later I'd find something that needed winchin'. As soon as I got home, I attached it to the Bronco's trailer hitch, ran the power leads up front to the battery, and uprooted a defunct satellite dish behind my house. Later I used the Towpower for something more like its intended purpose—winching a 1939 Ford up onto a tow dolly for a trip to the mechanic. Look, it's not a Warn XD9000, but for the money the Reese is a great thing to stash in your garage for those occasional winch-specific situations. As the mechanic said when I dropped off the Ford, "Great. Now, I've gotta get that."

THIS MONTH IN INFOTAINMENT

ONE SCREEN TO DISPLAY THEM ALL

If you want to have Apple's CarPlay or Google's Android Auto in the dash but don't want to buy the new car that surrounds it, consider Pioneer's NEX line of Android-based in-dash receivers that, in addition to their standard screens, run both interfaces. Just connect your phone via a cable to display a modified version of its screen. Prices range from $700 to $1,400.

GEAR TEST: PHOTOGRAPHS BY MIKE BASHER

5 Proven Ways to Get Better Protection for Your Home

How to get protection and avoid getting ripped off—recommended by Tech Experts, Personal Finance Wizards, and Authorities in Home Security

1 Make sure it's wireless.
"Wired" alarms are vulnerable—a burglar can snip one wire and shut down your whole system. A wireless system protects your home even if a burglar cuts your power.

2 Compare monthly fees.
Many home security companies will charge you outrageous fees of over $50 per month. It's possible to find the exact same protection for less.

3 Look for U.L. Listed
professional monitoring to send the police if there's an emergency at your house. U.L. Listed means the monitoring centers are rigorously inspected every 6 months to ensure you get the highest caliber protection.

4 Watch out for sneaky "Gotchas."
They're usually buried deep in the fine print of a home security contract. Here's an example from a real home security company's contract:

> 3. INCREASE IN CHARGES. [redacted] has the right to increase the annual service charge at any time after the first year.

5 Whatever you do, don't sign a long-term contract. Home security contracts make it impossible to cancel. You get locked in for 3 years (or more) and committed to thousands of dollars in payments.

1
BASE PRICE: $32,045
EPA MILEAGE: 21 mpg city/ 28 mpg highway

2
BASE PRICE: $61,460
EPA MILEAGE: 16 mpg city/ 24 mpg highway

3
BASE PRICE: $25,745
EPA MILEAGE: 25 mpg city/ 33 mpg highway

1 2015 NISSAN MURANO AWD

Here's the problem with crossovers: Most of them look like someone drew doors and windows on a Grade A free-range egg and scaled it up to car size. They're not ugly—just interchangeable. Not so with the new 2015 Murano. With its "floating" roof created by blacked-out cabin pillars and psychedelic interior trim, the Murano is one of the rare crossovers that dares to assert a distinctive point of view.

No, it doesn't drive all that differently from the old one. There's still a 3.5-liter V-6 running through a continuously variable transmission. But a 130-pound weight loss and sleeker aerodynamics mean fuel efficiency goes up 20 percent. And inside, the design details make a big leap. For instance, lots of companies use fake, plastic wood, but they always try to make it look like real wood. On Muranos with interiors like a P. Diddy white party, the fake wood looks like birch from planet Blargnor. Hey, if you're gonna go fake, go outrageously fake.

The seats are funky too. Nissan calls them "NASA-inspired zero-gravity" seats, but I still weighed the same whether I sat in one or not. They are quite comfortable. And the rear seats have high-speed heaters, to help cut down on the complaining from abaft.

Nissan's products fall into two categories: the safe ones, like the Rogue and Altima, and the crazier ones, like the Juke and Leaf. Well, Murano, welcome to the wild side.

2 2016 CADILLAC ATS-V

From the outside the Cadillac ATS-V doesn't sound like much. On a straightaway at Virginia International Raceway, the ATS-V hauls past me with a muted whoosh, its twin turbochargers smothering the 3.6-liter V-6's rowdy cackle. Inside the car, though, it's a different situation. The stereo system amps up the sound of the engine, blaring a backing track to add some auditory drama. Hey, man, is that *Freedom Rock*? Well, turn it up!

The soundtrack enhancement is the only bit of artifice on a car that strives to deliver honest communication. Like the lesser ATS models, the V wants to tell you what's happening down at the contact patches all the time. The car just feels good—even the steering wheel itself is firm so as not to dilute feedback with mushy padding. While you can appreciate conscientious chassis tuning at 25 mph, Caddy's V-Series cars are built for the track. And the ATS-V is a monster on the track.

With Magnetic Ride Control suspension and Brembo brakes, you take it for granted that the ATS-V will corner and stop hard enough to make your neck sore. The real revelation is the 464-hp engine, Cadillac's first twin-turbo V-6 and a nice piece of engineering. Its top speed is a fairly ludicrous 189 mph. The ATS-V is the latest affirmation that, these days, the most uncompromising hardcore sport sedans come from Cadillac.

3 2015 SUBARU OUTBACK 2.5i

It's a regular ritual: I climb into a new car, find the window sticker bearing the price, and then spend a few moments indulging in quiet despair. So it was with great relief and enthusiasm that I eyed the Outback's sticker and found a grand total of less than $30,000. Hey, that's . . . that's pretty reasonable! Especially for a big all-wheel-drive wagon loaded with worthwhile goodies like adaptive cruise control and pre-collision braking. Sane prices are one reason that Subaru topped half a million sales last year, riding a seven-year growth streak.

The Outback was redesigned for 2015, and the changes are mostly for the better. The interior is much improved, and there's a little more room inside. On the downside, the only transmission is a continuously variable automatic. They do give you shift paddles, so when the mood strikes you can pretend you have real gears.

Transmission aside, I'm overjoyed that a car as weird as this one is so popular. Here we have a station wagon with 8.7 inches of ground clearance, powered by a growly, horizontally opposed four-cylinder running through a robust all-wheel-drive system that can actually send the majority of the torque to the rear axle. Five people should want something like that, and they're all blacksmiths in Vermont. Well, damned if this thing doesn't make you want to buy an anvil and pack for Montpelier. You go, Subaru.

THE FIVE-WORD REVIEW

2015 INFINITI QX80
It's beautiful on the inside.

2016 NISSAN MAXIMA
Three hundred horses standard. Slick.

2015 FERRARI CALIFORNIA T
If you can, get one.

Dupli-Color® Scratch Fix All-in-1™

The ultimate tool for vehicle scratch and chip repair.

Dupli-Color® Scratch Fix All-in-1™ is the only brand with colors tested and approved by vehicle manufacturers for a perfect match to the original factory finish when restoring a scratch or chip.

The New Scratch Fix All-in-1 tool helps you fix it easy and fix it right...in your garage. Grab your color today at your local automotive retailer.

Learn How

Like Us, Follow Us, Watch Us, Visit Us

duplicolor.com

1. Prep it.

Abrasive tip removes loose paint & rust.

2. Paint it.

Pen tip for fine scratches.

Brush end for larger chips.

3. Seal it.

Clear coat to seal, protect & ensure a perfect factory matched finish.

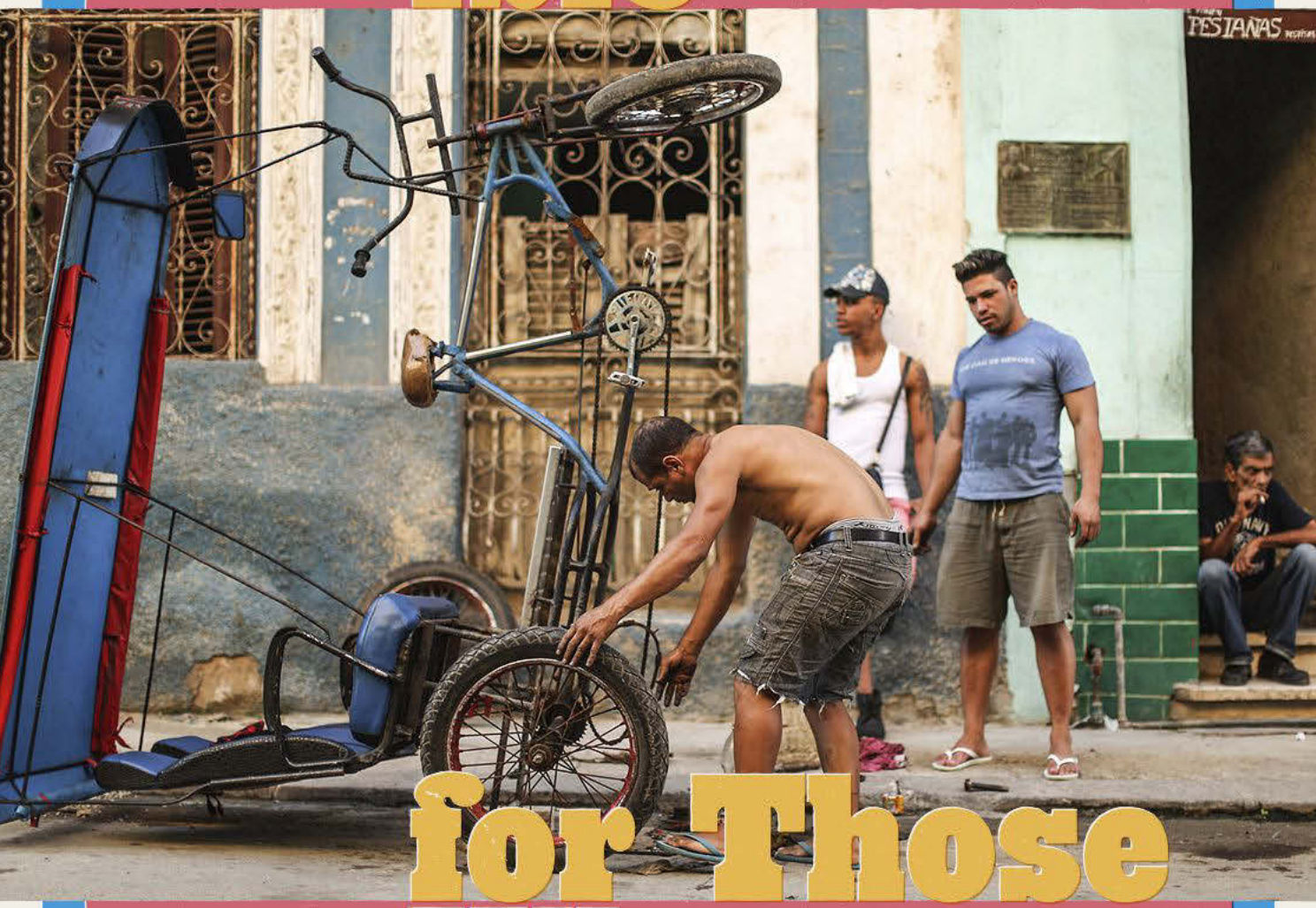
COLOR VEHICLE MANUFACTURER APPROVED

REPORT: CUBA

"Nothing Is Impossible for Those Who Fight"

Popular Mechanics goes to Cuba and finds a people devoted to hard work and ingenuity—often by necessity.

BY KEVIN DUPZYK



ON OUR SECOND DAY IN CUBA, we saw in one humdrum, ten-minute transaction a clue to the way life is lived in a country where daily life is often a challenge.

We had hired a man called Francel to drive us from Trinidad, a five-hundred-year-old town on Cuba's south shore, to Varadero, a resort town three and a half hours northwest. Francel was tall and thin and wore black, just like his car, a mid-1990s Peugeot. At twenty years old, it looked boxy and dated, but it was newer and in better shape than most cars in the country—it's not like everyone in Cuba drives a well-preserved American classic, the way you hear about. The Peugeot's floor mats were red plastic with a diamond-plate pattern. The air conditioning worked and so did the seat belts, both noteworthy. Every window was tinted dark with the exception of small cutouts so Francel could see the side-view mirrors. Inexplicably, the cutouts were the shape of the Apple logo.

Just outside Trinidad, Francel pulled off the road into the side yard of a small house. A man with no shirt on sat on a chair out front, just sitting.

Francel drove around back into a small parking space under a split-rail carport with corrugated-steel siding. At the next house over, across a small field, I saw a pig and a chicken lazing in the sun. The man from the front appeared and retrieved a gas can.

They barely spoke to each other, Francel and this man. They were operating within an invisible system. This transaction was, in fact, part of the vast and intricate web of improvised systems that constitutes the only way Cuba truly functions. Multiple generations of life with rationed food, little money, and a government set on isolation have produced a resourceful people. We humans are indeed a creative little animal, and we find ways to help ourselves. Where I live, we have the luxury of exercising creativity for fun. In Cuba, they have to be creative just to live.

Once the man had finished filling the tank of the Peugeot, Francel fired up the car and we drove off. I noticed the fuel gauge on his car didn't work. "How do you know when you're empty?" I asked.

He laughed.

MY FRIENDS AND I TRAVELED TO Cuba on a sort of curiosity vacation. We wanted to see Cuba before the country's newly normalized relations with the United States became truly normal. In America the maker movement is at its height, a wave of people building and making and creating things with technologies that improve by the day. In Cuba, they've had a maker movement since 1960, fueled largely by necessity. I wanted to see if the instincts were the same.

We spent our first three days in Havana in a *casa particular,* a private home that rents rooms to tourists. It works much like Airbnb, but it's a system the Cuban government formalized in 1997. We had booked a room in Casa Leticia, one of the most highly rated casas in Vedado, which, according to the Internet, is the hippest neighborhood in Havana.

A cab from the airport dropped us off in front of the casa. The houses here were built right up to the crumbling sidewalks, two or three stories high, and wore faded paint stripped to dirty pastel shades by the salty ocean air. An old man in a red Havana Club vest sat alone on the sidewalk. Two skinny dogs lay on their sides panting. I thought there'd been a mistake. We double-checked the address. We were in the right place. Upon closer examination I saw a sticker above the door of the inauspicious building that was Casa Leticia: "2014 Winner, TripAdvisor Certificate of Excellence."

We rang the doorbell, and Leticia herself opened the gate. A large, sunny interior courtyard was paved with perfect ceramic tile, lush with greenery, and outfitted with white wrought-iron patio furniture. A peristyle surrounded the courtyard, yellow-painted columns complementing green-and-blue-striped awnings hung between them. Inside, the immaculate house had ornately painted twenty-foot ceilings and—crucially, it would turn out—a bathroom, complete with shiny new fixtures.

Leticia, who was in her fifties, was short with blond hair and fair skin. Her eyes never stopped smiling and dimples appeared on her cheeks when she talked. She funneled us toward the dining room, where we filled out the simple paperwork that logged our stay. Then she opened a handsomely decorated liquor cabinet in the corner of the room and produced three glasses and a bottle of Havana Club, poured us each a shot, and gave us advice for our stay or for life or both.

"You are three young men. Watch out for *chicas*. There is no such thing as love at first sight.

"You will come across people who are very impressive. Well traveled. They will speak multiple languages and know places to take you. But when you get to the end of the day and you've paid for everything, they're gone.

"You are here because of the new Obama laws. Visit Cuba with an open mind."

Leticia had a system for everything.

HAVANA IS A GREAT CRUMBLING beauty in a constant state of repair. Walking through the neighborhood near Leticia's house, we saw some men pulling cinder blocks uphill on a wooden pallet outfitted with casters and a handle made of bent rebar. First appearances—appearances in general—are deceiving. We came to learn that the old man with the red vest was a government employee, hired to watch cars overnight. Men in red vests were stationed around the city, standing guard over the population of famed American classics and less familiar foreign makes like Lada, made in Russia, and Geely, which is Chinese. Buildings in the city seemed to grow taller as they approached the water, where a great walkable boulevard called the Malecón traces the shore. Like Casa Leticia, many buildings were pitiable on the outside but astonishing on the inside. According to our guidebook, three buildings collapse per day. When their guts spill out, I'm sure they are beautiful.

Our first night we had dinner with a computer programmer named Medardo Rodriguez. I had read about an entrepreneurship club he ran and contacted him before our trip. Medardo met us at the Hotel Nacional, one of the few buildings whose outside is as immaculate as the inside. It sits on a bluff over Havana Bay, outdoor seating arranged around two incongruous bits of decor: cannons from the armory that preceded the hotel on the site and an art installation riffing on bathrooms. A porcelain toilet stood on a tiled and graffitied pedestal. A lifeguard tower had a commode for a chair. Creative reclamation.

Medardo was older than I'd expected for the leader of a group devoted to developing a startup culture where virtually none exists. Balding and pushing forty, he wore trendy plastic glasses and bounced while he walked. He reminded me of a grizzled Silicon Valley veteran who'd survived the dot-com bubble with his enthusiasm for technology intact.

At the restaurant Medardo explained his role in the Merchise Startup Circle, the organization trying to engage and develop entrepreneurs in Cuba. The group grew out of a programming collective Medardo founded at the University

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Mecánica Popular began publication in May 1947. Above, covers from November 1963 and April 1957.

"Marta Abreu" of Las Villas in central Cuba in the early 1990s. He taught programming as a practice of creative thinking. The group developed video games and even a Web browser, but broke up in the early 2000s. It is difficult to maintain a programming collective in a country where the number of citizens with access to the Internet hovers at around 5 percent.

That hasn't stopped the group from reforming under a new guise. Creative thinking properly focused is entrepreneurship. And to Medardo, being disconnected from the rest of the world has in fact been the very stimulus of his most creative thinking. He learned from programming that being connected can be a distraction. Perhaps, he wondered, programmers learn better without the buzzing Internet constantly robbing their attentiveness. How easily might someone else's creativity replace our own, if we let it?

As we were eating and talking, life in the courtyard suddenly stopped. The space had been full of the din of other tables and friends, a vending-machine hum, the clatter of the kitchen. Suddenly, silence. The power had gone out.

"Now you are knowing the real Cuba," Medardo said.

As workers retrieved portable lights, we strangers simultaneously pulled out our smartphones, turned on their flashlights, and placed them on the table. Someone said the light was too harsh. "Use the saltshaker," said a voice in the crowd. My friend put one over his phone's light. The crystals softened its glow. Each of us who could find a saltshaker did the same, and, just like that, we invented mood lighting.

AFTER HAVANA WE VISITED TRINIDAD, A COLONIAL TOWN with cobblestone streets. We stayed at Casa Balbina, where our host, Ricardo, was a retired chemistry professor. I told him I worked for an American magazine called Popular Mechanics, and he laughed and explained that Cuba used to have a magazine called *Mecánica Popular*. Ricardo had to be in his eighties, old enough to have read *Mecánica Popular,* the Spanish-language edition of Popular Mechanics, before the embargo started in 1960. I've heard some older Cubans still have collections of them. They might be on the shelf next to *Con Nuestros Propios Esfuerzos* ("With Our Own Efforts"), a government publication from the post-Soviet era that provided shop notes for Cubans trying to get by as their economy collapsed. In Popular Mechanics, the motto for our Shop Notes section is "Easy Ways to Do Hard Things." *Con Nuestros Propios Esfuerzos* also has a motto, from Fidel Castro: "Nothing Is Impossible for Those Who Fight."

In early 1960 *Mecánica Popular* split into two local editions: one for South America, and one for Mexico and the Caribbean. Trinidad feels like a city paused in that moment. Built on an easy slope up from the Caribbean shore, it is an anthill of workers. A man cut tile on a table saw in the dark anteroom of his home. Another tossed cinder blocks from a cart on the street to a fellow working inside. The cobblestones had been removed from a hillside street to make way for plumbing work. On another street neat stacks of stones cordoned off a repaving project, the way bright orange cones would be used in the United States. In Cuba, when a system doesn't exist, they make one.

Trudging uphill to make a dinner reservation, we saw a man working alone on a red brick wall. He spread mortar in thick gray slabs and placed bricks in an alternating pattern—header, stretcher, header, stretcher. It was hot and sweaty work on a hot and sweaty day, but he wore protective long sleeves and pants and a work belt. He reminded me of the construction workers on the tract homes in Sacramento, California, where I grew up. The summer sun routinely pushed temperatures above 100 degrees, but practicality outweighed comfort. They wore jeans and long flannel.

We ate dinner at a *paladar,* a privately owned restaurant that was part of a formalized system analogous to that of the casas particulares. The waiters were trained by the state-owned catering company. They were dressed formally and brought out entrées on platters covered with silver lids, which they removed from everyone's dish at exactly the same time.

Over dinner we talked about what we had seen, and what we had not seen. We had been to multiple restaurants that offered only a small portion of the items on their menus. We had tried to visit museums and been foiled by idiosyncratic schedules. We had made an attempt to buy a wireless Internet card at the state telecom office during a service outage. "The most productive person we've seen was throwing bricks," one of my friends said.

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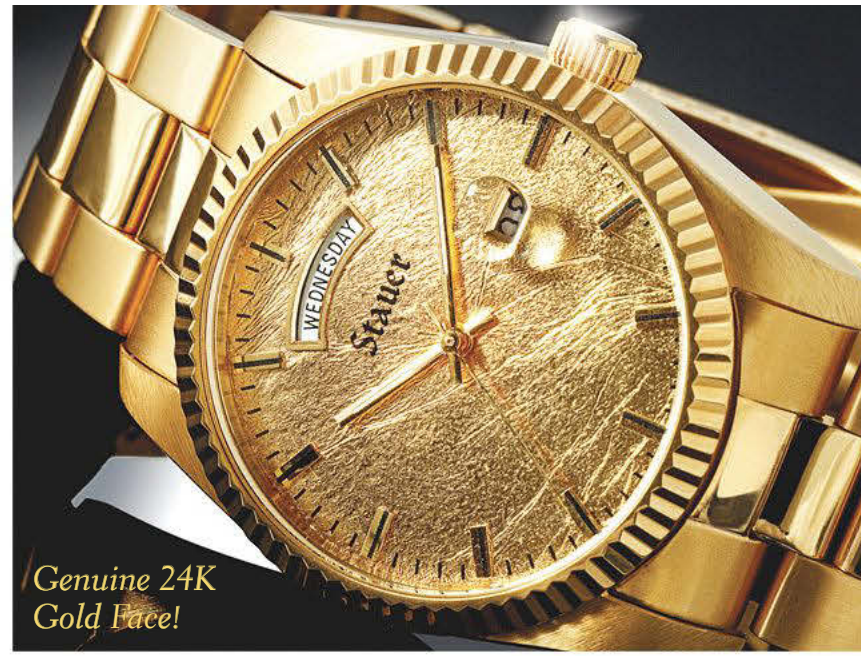

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Part of the fascination of seeing men perform manual labor in Cuba is that, unlike in the U.S., the other options are less obvious, and the work itself seemed to animate the people doing it. We had seen plenty of Cubans who had jobs in air-conditioned rooms: rental-car clerks, people who worked in stores. In the U.S. those would be seen as better jobs than building a brick wall. On this street in Trinidad, the opposite felt true.

After dinner—chicken and lamb, with a buffet of sides like rice and beans and tropical fruits—when we were walking home, we saw the bricklayer's wall nearly finished.

IT'S FUNNY, I almost didn't get to go to Cuba at all. My two buddies went through Cuban immigration without a hitch. I didn't have any problems at first, but when my suitcase went through the scanner, it raised a red flag. I had brought seventeen copies of the June issue of Popular Mechanics, thinking I would meet people who might like it—people who've managed to maintain a 1950 Chevrolet for sixty-five years, or who keep buildings from turning to rubble, or who've cast livelihoods from the raw materials of everyday life. People who have learned to improvise to the point where improvisation becomes the way to keep living. But I'd overlooked the possibility that a suitcase full of American magazines might look like propaganda, especially considering that the headline on the cover of the "Maker Nation" issue I'd brought was "How *You* Can Join the Revolution."

The first customs agent asked if I spoke Spanish (no). She brought over a second agent with better English to ask me to explain myself. I tried to articulate what Popular Mechanics is about, then I tried to make up a story about giving the magazines to my friends to take home, but the language barrier made it difficult—and, also, that made no sense. Seeing the commotion, a third agent came over and immediately started examining the magazine. Things began to turn. I continued arguing my case, but now I was watching this third agent. He flipped through the magazine, stopping on all the best pages: the beautiful things, the projects, the makers. I struggled for words. He saw something he recognized. PM

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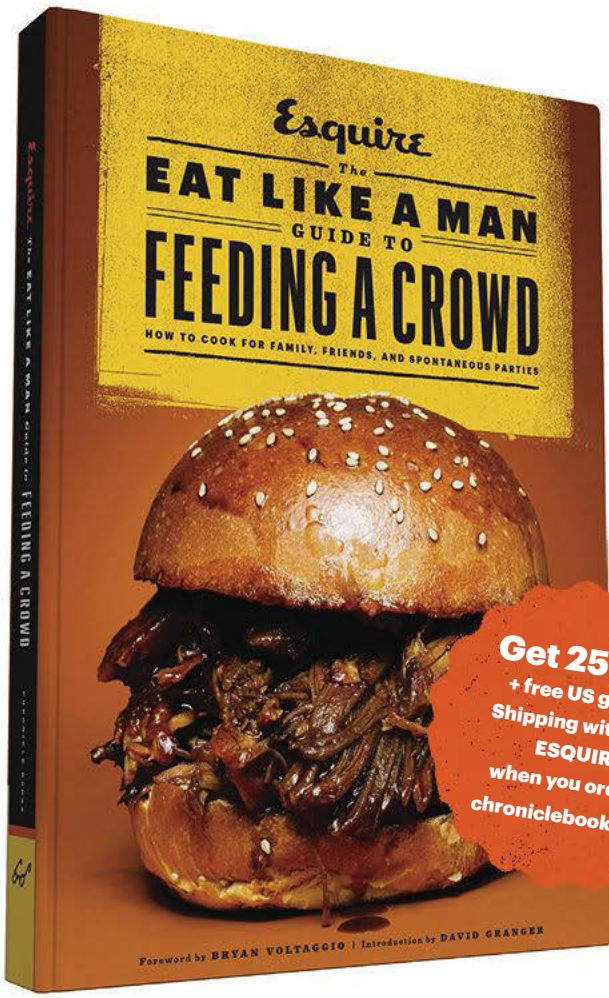

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A BEAUT

POPULAR MECHANICS

Joe Miller built his family's home in Peacham, Vermont, himself. On their small farm he'd put his young son and daughter to work forging door hinges and hooks in his blacksmithing shop or assembling cabinets and drawers for carpentry projects. Joe used horses—no tractor—to haul wood from the forest behind the farm. To tend to those horses, he accumulated piles of horseshoe rasps, the high-carbon-steel files used to maintain hooves.

Joe's daughter, Chelsea, was watching. When her father fell ill for a spell in 2011, Chelsea, now grown, returned home to Vermont from New York. In between caring for her father, she helped her brother make a hunting knife from one of the old rasps. Then she tried making a knife herself, reviving the blacksmithing skills she'd picked up as a kid. The tinkering became an obsession, which turned into a skill—she went on to apprentice with a Vermont knife-maker. It has since become her livelihood.

Miller takes 17-inch-long rasps and transforms them into one-of-a-kind chef knives. There are functional benefits to repurposing the old tools. The steel is extremely strong. And the thick, crosshatched teeth of the files, which she leaves intact, become a grater built right into the blade. She's enlisted her dad to cut and shape the knife patterns with a century-old bench grinder. He sends batches of proto knives, along with excess metal to be made into smaller cheese knives, from Vermont to her workshop in Brooklyn. There Miller hones the blades from their quarter-inch thickness to a sharpened edge, then affixes maple or walnut handles, pieces of Vermont forest from the family farm.

It's a time-consuming process—Miller is able to produce only about six knives a week. She does most of the work on her own, with the help of Joe and an assistant. It's the only way she knows: "That's the way I grew up. If you're hungry, then you go out and plant something and harvest it. If you're lonely, you go out and you make friends. Everything is available to me as long as I'm willing to work for it myself." Including an heirloom-quality knife when all you have is a rusty old file. **—MATT GOULET**

The Knife-Maker

Miller had been living in New York to pursue an acting career before she came back home and rediscovered her propensity for reshaping steel.

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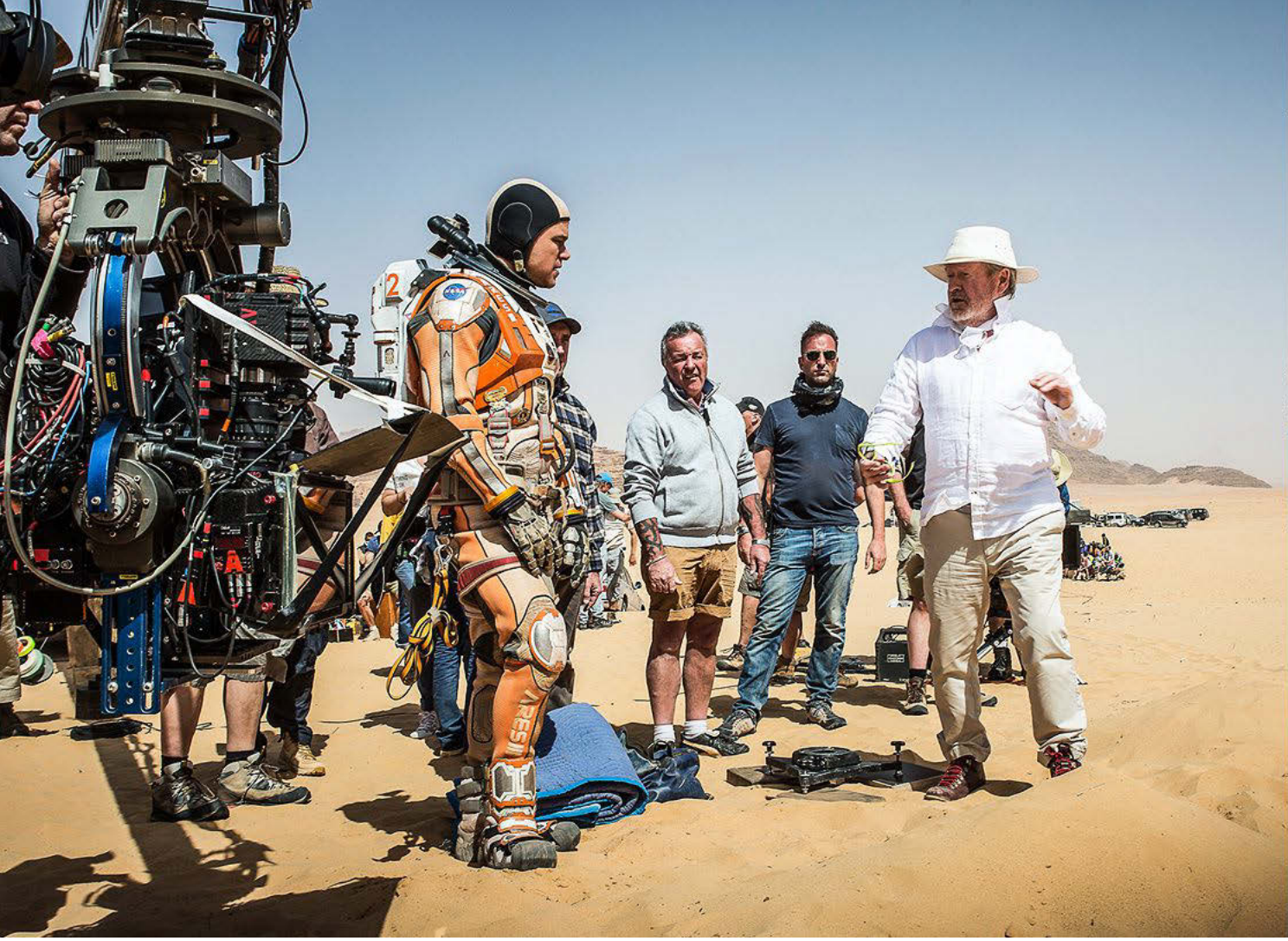
THE MASTER

RIDLEY SCOTT is one of the most ambitious and successful directors of our time. In a fifty-year career—*Alien, Blade Runner, Thelma & Louise, Gladiator, Black Hawk Down, American Gangster, Exodus: Gods and Kings*—he has created astonishing worlds that challenge the limits of endurance and possibility, but never reality. With his new film, *The Martian,* Scott adds a new dimension to his legacy: Science, a frequent backdrop to the stories he tells, becomes a main character.

BY TOM CHIARELLA



WHEN YOU STAND ON MARS, IT'S HARD TO figure the horizon. It looks a smidge too close, disconcertingly dim. Dark even. The color of the sky above you? Sort of blue, with a green tinge. It's vast, unlike anyplace else you've seen. Distance is the first puzzle of this place. Point A to point B stuff. How to judge? You spitball it. How far could you throw a baseball here? Or drive a golf ball? What about repeated Frisbee throws? How far would it have to go before you hit some obstacle? A wall, a drop-off, whatever is out there. Everybody knows things sail on Mars, so you could really drive that golf ball. But the soil would be a problem. While it's just as red as you might expect, it's also sandy, loose, and untamped by gravity. Whatever you threw, whatever you struck or hurled, when it hit the Martian surface, it wouldn't roll. Mars has no roll.

Not this Mars anyway. This place is a construction, a cinematic vision built on one of the world's largest soundstages, outside Budapest, Hungary. There's a red-dirt floor—composed of twenty-four hundred cubic tons of soil mixed and remixed to match the texture and hue of Wadi Rum in Jordan, where the exterior scenes were shot—and a nearly abandoned astronaut habitat in the distance. This is where Ridley Scott is shooting a large portion of *The Martian* (out October 2), starring Matt Damon as a NASA astronaut stranded on Mars after an emergency evacuation.

Scott, who has previously crafted notable science-fiction movies of the first order (*Alien* and *Blade Runner*) and at least one of the other order (*Prometheus*) stands working the problem of the day, as he is wont, hunched over a bank of playback monitors. He's seventy-seven, looks younger. White-bearded and still has some red in his hair, cozy in a fleece jacket. His boots, more than anyone's here, are skinned in a fine, red Martian dust, and his ball cap is on the table. Scott is not imperious when he works. He doesn't prowl the soundstage. He's its pivot point. More foreman than auteur. Scott will glance to make eye contact, but refuses to cast about for it. You either look right at him or you

Far left: The three-time Oscar nominee directs Matt Damon in Wadi Rum, Jordan, where *Lawrence of Arabia* was also filmed. Left: The soundstage version of NASA. Below: Damon on the set in Budapest, Hungary.

don't. You're one kind or the other. He doesn't need any favors or new pals. The man is a knight of the realm after all. There's a businesslike urgency in his voice, and a muted though undeniable enthusiasm for detail, which you are assumed to share. Concocting a story through film is surely a kind of puzzle. Concocting a planet to tell it is more like architectural engineering.

When Ridley Scott works, you see only his back, bent low, as he stares intently into the monitor, giving notes. Eventually Scott speaks over his shoulder. There's no message in the gesture—this is simply Ridley Scott on the job. Quiet. Undistracted. Calculating. The crew knows he is present. A soundstage is always quiet, built to be a place where extraneous noise goes to die, and Scott makes the whole place even more quiet when he's working. His lieutenants—department directors, assistant director, cinematographer—are quite often Ridley Scott lifers, who untangle every twist and interpretation—camera position, lens, lighting, pitch and yaw of the shot rotation—alongside him. When he's not quite happy, Scott asks for another take. When he's happy, he asks for another to see what it might bring. He points to the position of a light bank, yammers with his assistant director before straightening up to regard the rotation pattern of three cameras used for this one shot, each tracked to gyroscope around the exterior portion of a hatch. From the hatch, in this moment in the film, an astronaut will face the stark light from the sun and the distances—grand and small—across space. Three cameras, whirling in coursing, steady arcs. Arms folded now, Scott assesses the scene: "This is an important moment," he says. "It matters to the story and the character. I like multiple cameras here because space has a jarring quality at this moment. The man is very still, but this ship is in orbit. It tips and moves, and it isn't ideal for rescue. It's just highly disorienting to poke your head out, even into daylight."

It's an eleven-second shot in the movie. It's taken hours to set up and another hour or two to shoot. They've run it twice already. "One more," he declares. And maybe one more after that.

FOR SCOTT, IT BEGINS with a pencil. "My editorial process is simply drawing. I'm a paper-and-pencil man. I love to draw, and I use it as a means of seeing a story from its beginning to its end. I just draw panel after panel, until I can start to see the place and the character set against it. I tried to draw each problem Watney was faced with, until I could really see the planet in front of him, the technology he lives in, and see him set within the incredible isolation of both."

Scott has directed twenty-two commercial films since 1977, and while nobody in the real world judges a person by his movie gross, it should be said that Scott has grossed more than $1.3 billion on his films in the U.S. alone. More to the point, he's never failed to vary the genre, setting, or historical time period of the films he chooses to make. *Alien, Blade Runner, Thelma & Louise, Gladiator, G.I. Jane, Matchstick Men, Black Hawk Down, American Gangster, Prometheus, Exodus: Gods and Men.* Many of his films are cultural touchstones, rich atmospheric gems, featuring surprisingly strong women (think Ripley, Pris, Thelma and/or Louise, G.I. Jane herself) and signature moments (xenomorph in the air vent, the fingertips of the gladiator brushing the wheat on his farm, the dark chaos of Mogadishu). Scott's imprint is on the life and commerce of the stories we love, none the same as the last or the next. If *Prometheus* lurched from the gritty realism of *Alien*, *The Martian* claims a space of its

"Alien is a C film elevated to an A film, honestly, by it being well done and a great monster."

own in science fiction—a near-future proposition in which the limits and capabilities of existing technologies become essential plot points. No warp drive. No wormholes. No grand speculation.

Early on, Damon's character, Mark Watney, declares that he will have to "science the shit out of this" if he hopes to survive. That's the bet of the movie, that science itself—accurately portrayed, unceasingly up-to-date science—can be used to create the tension, suspense, and existential dread of a great castaway story. Scott and *The Martian* are going to science the shit out of that story, and bet that we can all keep up.

Scott's father was a lifelong officer in the British Royal Engineers, which might be an easy explanation for the habit of sussing out problems with that pencil and paper. It's not that simple, however. "My mother was the real sergeant major of the family," Scott says. "She made sure that we confronted jobs and figured them out. Fixing things, making our own repairs, darning socks. We were asked to figure out the mechanics of a problem and solve it by our own selves."

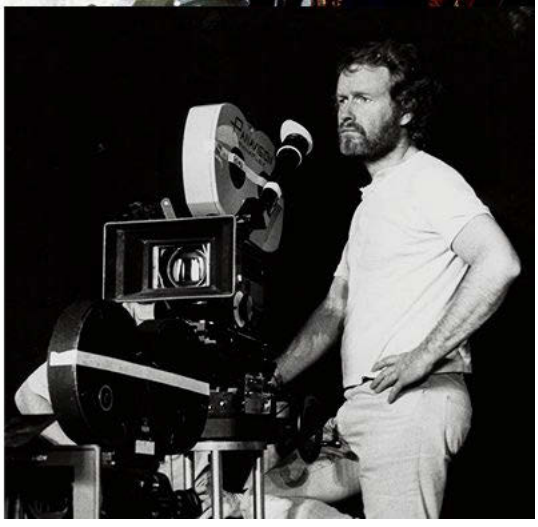
Similarly, Scott trusts the people he's hired to solve the problems of the story. Many of them have worked with him for thirty years. "When we filmed *Gladiator*, I had a department responsible for creating these catapults for the opening battle sequence. They had to really work. We needed them to create an inferno of fear. We knew that the actual catapults used by the Roman army could throw burning-hot paraffin wax at the enemy. Building a full-size catapult is quite an undertaking," Scott says. "But the catapult we built threw the wax eighty yards. I think." He ho-hums the shortfall. "It says more about the magnificent Roman engineering than any failure on our part. Detail is essential. Even so, you can't get held up by it."

SCOTT WILL TALK propulsion systems, on-site hydrogen collection, and launch capability with the best of them. It feels important to understand. And fun. The sweep of his career shows that. A reverence for the wealth of things we're capable of creating. Chariots. Con games. Deep-space transport. Crime syndicates. Replicant technology. Road trips. Every story an exploration of capabilities and limits and the means by which we exceed them. Or fail to. "Watney is locked on Mars by the genius of technology. As advanced as it is, it's still a limited inventory, which he assesses constantly as it breaks down, gets used up, falls apart." And like any storyteller, Scott sees character as a story's most detailed construction. Take Watney: "His ingenuity, his scientific understanding—that's what frees him from the original function of what he's been left with. Look at how he farms."

As efforts toward rescue pick up on Earth, Watney, a trained botanist, must develop a way to continually farm enough potatoes to live on, even though Martian soil is incapable of growing anything. To create functional soil, Watney turns to what no one would want: the human feces stored in vacuum packs by NASA for the planned return to Earth. "NASA collects, vacuum seals, and labels every bit of solid human waste. The plan is that once the astronauts get home, scientists unseal it and study what it shows about the effects of space travel on the body. It's very businesslike," Scott says. "Watney creates a farm out of it right in his own living space. It's quite advanced in

MARTIANS IN POPULAR CULTURE

			Threat to humans	Vulnerability
1897	WAR OF THE WORLDS		high	• Human bacteria
1948	MARVIN THE MARTIAN		moderate	• Bugs Bunny, Michael Jordan
1950	THE MARTIAN CHRONICLES		low	• Germs
1963	MY FAVORITE MARTIAN		low	• Detective Brennan
1976	THE FACE ON MARS		low	• Higher resolution photography
1990	TOTAL RECALL		moderate	• Tri-breasted women
1996	MARS ATTACKS!		high	• The falsetto yodeling of Slim Whitman
2012	JOHN CARTER		high	• Tim Riggins
2015	THE MARTIAN		low	• Needs food, oxygen, and a risky experiment to live



Left: Scott on the set of *Blade Runner* with Harrison Ford in 1981. The film is widely praised for its inventive effects technology, much of which was done by shooting different elements of the same scene, over and over, and then layering them on top of one another. Right: On the set of *Alien* with Sigourney Weaver in 1978. Bottom right: Behind the camera for *Alien*.

terms of science and process, and yet it's got a primitive point on it."

"The exploration of Mars is not unlike a pioneer journey in the American West," Scott says. "When wagon trains went out from the East, the distance they had to travel was the only given. A known quantity. Getting there, stopping at the right spot for the night, finding drinking water—these were the difficulties. Scouts were the highest paid members of a trip because they would ride ahead, examine the obstacles—rivers, mountain ranges, native populations. They were the most knowledgeable, inventive, ingenious individuals available. Astronauts are our scouts. Watney has a bit of Kit Carson in him," Scott says, referencing the legendary nineteenth-century American frontiersman. "He's funny. He's capable. He fights to live in the wild. Watney is one part entertainer, one part athlete. Even a kind of survivalist. Carson was all that. Watney is a little glib, and even fatalistic, in the face of what he has to do. He's not feeling sorry for himself. It's really sort of American, I suppose." Ask the castaway himself: Matt Damon, scraggly bearded and a little gaunt, there on the far side of Budapest, on this Mars. "One of the puzzles for Ridley was creating a sense of the terror of being a hundred million miles from another human being and still allowing it to be funny. Acting is all about the other person, what's going on with them, what they present to you," Damon says during a break in shooting. He gestures toward the soundstage. "Here, the character has only himself. I came to see the only other person really was Ridley."

SCOTT WILL TALK PROPULSION SYSTEMS, ON-SITE HYDROGEN COLLECTION, AND LAUNCH CAPABILITY WITH THE BEST OF THEM.

Damon is wearing his spacesuit, sitting on a long folding table, his gloved hand inches from a bag of potato chips left over from the craft table. "But the movie is way more than a castaway story. That's what Ridley does. There's this whole other side of the story. I think there are fifty-five actors in this movie. It's like they shot three separate movies on three separate parts of the planet. It's the entirety of everybody working to come get him. It's a rescue story too."

On the complications of pulling together such a story, Scott is preternaturally chill. (Knight of the realm!) He's done it two dozen times—mixing the levels of storytelling, breaking the job into discrete tasks, assessing a means to reproduce the tension of a human circumstance even in an inhuman place. "I think of the movie as having four separate universes. There's NASA, there's JPL [NASA's Jet Propulsion Laboratory], there's the story of the crew on the ship, and then there's the story on the surface, the Robinson Crusoe story. So the key thing is that it has to be funny, or else the sheer wealth of information starts to feel overwhelming."

This may be the thing that makes it positively cool to talk with Ridley Scott. Yes, there's the elegant demeanor. Notable. Very nice. But most of all, Ridley Scott is an enthusiast. He loves a problem. He takes to a set of characters and revels in the way they confront their problems. Ripley solves a dozen on the way to her escape vessel, then a half dozen more. Thelma and Louise run from, and then into, their problems. Joyfully. Consider the gladiator, parsed by loyalty, by duty, by love. And now the one man, the astronaut and his measly bag of potatoes, and the millions of miles of space between the place he finds himself and his home. Problems. Imperfect people, fully drawn. Seen. And what Ridley Scott sees, Ridley Scott draws.

ON ANOTHER part of this Mars, they are blowing the hatch. It's a low-level effect, a small, controlled explosion performed at the end of the usable life of the lander-module component. A number of crew members have gathered to watch. Earplugs are distributed. Ridley Scott takes a quick look from the doorway and then moves on before they get to the actual explosion.

Filming is near its end on the soundstage. The hallways are dusted in red. Red footprints lead from food to banks of clipboards and then to the world outside. Sets are being broken down for storage. In every corner boxes of innocuous riggings and spare parts—clamps, rods, pads. This may be Ridley Scott's last look at this Mars. He's off to Jordan in the morning to finish shooting. The disassembly of this operation echoes the story it tells.

"At the very end, when it's evident Watney will be leaving one way or another, he sort of goes on a walkabout, because bizarrely he's become fond of this environment," Scott says. "And if we tell it right, people will get that about him. He's cleaning up, taking care of the assets for the next party, creating assets for the next person. He's been trained. He's an astronaut."

Then Ridley Scott carries on, down the dusty hallways. An assistant joins him, passes a message, and they change direction to another part of that world. You're looking at his back again, which means there's still work left to do, on this Mars and beyond. PM

"I still think it's one of the best films I've made."

MARS THE SCIEN

WHO WILL GET THERE FIRST?

A relatively unbiased analysis of the groups attempting to reach Mars, with real Vegas odds on their success by **Raphael Esparza** of docsports.com.

RUSSIAN FEDERAL SPACE AGENCY Russia announced a rocket that can move heavier payloads than any rocket currently in operation. According to President Vladimir Putin, in 2018 Russia will use this technology to launch the first manned missions from the motherland. (They typically launch from Kazakhstan.) **Vegas odds: 60:1.** "It's clear that Putin is serious."

CHINA NATIONAL SPACE ADMINISTRATION China didn't send a man to space until 2003, but they've been aggressive ever since. They're building an orbiting space station and looking to launch a rover to Mars in 2020. One of their taikonauts—what they call astronauts—was part of the Mars500 study in Moscow that tested long-term isolation in preparation for a long journey to the Red Planet. Their current plan is for a manned Mars mission between 2040 and 2060. **Vegas odds: 100:1.** "They are late to the party."

SPACEX Elon Musk wants to go to Mars, and he's built a company with the experience to do it. The contracts with NASA for supply runs are old news. SpaceX has moved on to experiments with recoverable rockets and GPS-guided landing platforms. Musk has already announced his intention to reveal the company's Mars Colonial Transporter before the end of the year. He says they have a spacesuit in the works too. **Vegas odds: 5:1.** "They have the desire and the funds."

INSPIRATION MARS Unlike the other organizations on this list, Inspiration Mars—led by Dennis Tito, the first tourist to go to space (for only $20 million)—doesn't plan to leave people on Mars. What it does plan to do is take advantage of a rare planetary alignment that will occur in 2021 to allow a pair of astronauts to fly by both Mars and Venus on a trip that lasts a mere 582 days. **Vegas odds: 25:1.** "If they don't actually touch down on Mars, does it count?"

NASA Although the low Earth orbit shuttle program was shuttered in 2011, NASA is at work on a new system of vehicles to take the next generation of missions into more distant orbit. The Space Launch System is a massive rocket that will propel an all-new manned spacecraft called *Orion* to near-Earth asteroids to develop the knowledge and skills to make possible a trip to Mars, which the agency estimates will occur in the 2030s. **Vegas odds: 80:1.** "If it weren't for the budget cuts, NASA would be the favorite."

MARS ONE Mars One offers one-way trips to the Red Planet, funded by broadcast advertising revenue brought in by its proposed reality show. The organization plans to use a series of missions starting in 2020 both to build up infrastructure and prove its technology before sending the first manned crew in 2026. From everything we can tell, it's a total scam. **Vegas odds: 15:1.** "If they do any of the stuff they claim they will, the group would be a huge sleeper."

THE MARS SOCIETY A major proponent of colonization, the Mars Society advocates a two-stage plan called Mars Direct. First, an unmanned craft journeys to Mars and generates rocket propellant by reacting hydrogen with the Martian atmosphere. A follow-up manned mission then arrives with a fabricated living space. The crew uses the living space as a base for exploration before taking the first ship back to Earth, leaving the living space behind. A few such cycles builds up a stock of habitats on the planet—and the beginnings of a Martian city. **Vegas odds: 9:1.** "No other group has as well-detailed a plan."

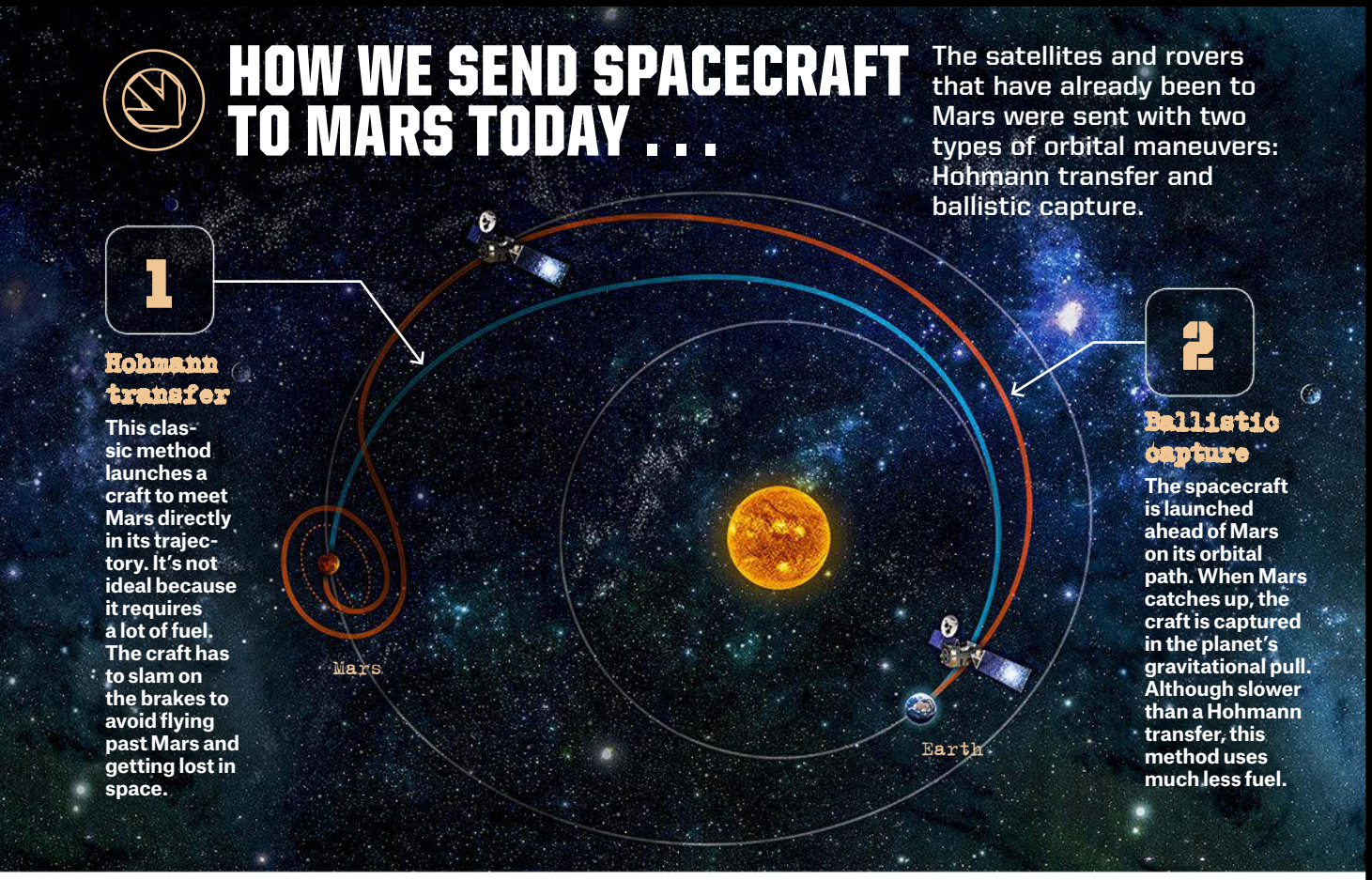
EUROPEAN SPACE AGENCY European governments currently have bigger concerns than outer space. **Vegas odds: 300:1.** "They may have teamed up with Russia to launch a Mars orbiter mission in 2016 and a rover in 2018, but even with help, I don't see Europe being the first."

ILLUSTRATIONS BY 5W INFOGRAPHICS

TIFIC COMPANION

HOW WE SEND SPACECRAFT TO MARS TODAY . . .

The satellites and rovers that have already been to Mars were sent with two types of orbital maneuvers: Hohmann transfer and ballistic capture.



1

Hohmann transfer

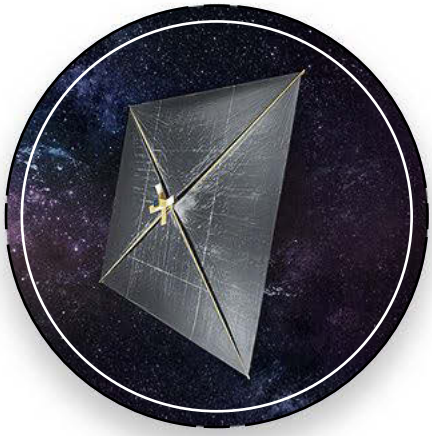
This classic method launches a craft to meet Mars directly in its trajectory. It's not ideal because it requires a lot of fuel. The craft has to slam on the brakes to avoid flying past Mars and getting lost in space.

2

Ballistic capture

The spacecraft is launched ahead of Mars on its orbital path. When Mars catches up, the craft is captured in the planet's gravitational pull. Although slower than a Hohmann transfer, this method uses much less fuel.

. . . AND HOW THOSE TRIPS MIGHT BE POWERED IN THE FUTURE



Solar Wind Sail

In space the massless photons that make up the sun's radiation have the same effect as wind on Earth. They constantly buffet spacecraft, so much so that NASA regularly corrects its trajectories for solar radiation. Instead of fighting that radiation, spacecraft can take advantage of it by incorporating a thin sail made of carbon fiber or aluminum-reinforced Mylar that propels the craft using the energy of the photons (left). With no need for expensive chemical fuel, solar sails offer a much cheaper alternative to traditional means of propulsion.

Nuclear Thermal Rocket

A nuclear reactor is used to superheat hydrogen, which, as the molecules expand, is forced through a small area to generate thrust. It does the same job as a chemical rocket, but uses about half as much fuel.

Ion Thruster

Ten times more efficient than a traditional chemical thruster, an ion thruster is well suited to long-distance missions. You know, like a trip to Mars. The engine ionizes xenon atoms, then propels the craft by electrically accelerating the ions out and into space.

SPACE VEGETABLES

What we'll need to grow and how to grow it.

Lettuce grows in a reduced-pressure atmosphere.

Keeping a team of astronauts fed for a three-year trip won't be easy, especially without Tang. According to Doug Ming, a planetary scientist at NASA's Mars Science Laboratory, one solution NASA is researching is growing plants in transit and on the surface of Mars. They've already developed a full list of twenty-three crops that, along with being hearty enough (with some tweaks) for the Martian environment, will create a nutritionally balanced vegetarian diet for the astronauts. On the menu: carrots, mushrooms, onions, peas, peanuts, soybeans, sweet potatoes, and more. Even strawberries.

Space crops will work double duty, providing food for the crew and regenerating oxygen through photosynthesis in artificial Earth environments. Some may be genetically modified for the cramped conditions of space life. (Wheat, for example, can be manipulated to grow shorter than its typical four feet.) And since Mars has very little growing space, lacks any real water in its soil, and is thus inhospitable to vegetation, all space plants will probably be grown hydroponically. Eventually scientists hope to be able to plant crops directly in Mars' soil. All they'll need is fertilizer. Luckily, the astronauts will be bringing that with them. Urine is naturally full of nitrogen, which Martian soil is short on, phosphorus, and potassium—all great fertilizers. Instead of watering the plants directly, astronauts will more likely filter out essential nutrients and turn the rest into usable water.

THE TROUBLE WITH LIVING THERE

If the trip doesn't kill you, one of these issues just might.

DAY LENGTH

Days on Mars are forty minutes longer than they are on Earth, which doesn't sound like a big deal, but Mars colonists will get out of sync with the circadian rhythms that govern things like sleep, hormone release, and body temperature very quickly. Expect a lot of light therapy.

RADIATION

In space astronauts receive about twenty times the radiation we do on Earth. Along with increased cancer risk, radiation can also have unknown effects on the heart, brain, bones, muscles, and other organs. (Scott Kelly's year in space will provide illuminating data in all of these categories.)

One of NASA's nightmares is that increased radiation levels will cause a loss of cognitive abilities. At the moment the best protection is to get astronauts to and from Mars as quickly as possible. Once they're there the planet's atmosphere will shield them, since they won't be hit from all sides, like in the shuttle. Shelters will shield them even more.

NASA limits astronauts' radiation exposure to no more than would increase their cancer risk by 3 percent. Travelers to Mars will likely be exposed to more than that, receiving a lifetime dose during their three-year mission. When they get back to Earth, they won't be allowed to return to space.

ILLNESS

Any trip to Mars will be closely monitored by NASA's Office of Planetary Protection to make sure that life from one planet doesn't infect the other. Protection starts with sterilizing spaceships' outer surfaces of microscopic Earth life. It also means disposing of human waste responsibly, often by storing it until the ship exits Mars' atmosphere, when it can be jettisoned into space.

The OPP also hopes to protect the astronauts from returning with the Martian version of the cold or chicken pox. The ships will be sterilized upon reentry, and astronauts will be tested en route. If they are sick, good luck to them. NASA currently has no plan in place for dealing with space sickness. Developing a protocol is essential before astronauts leave for Mars so that decisions aren't made in a crisis situation. Otherwise, law often replicates maritime law, which states that any plagued ship must be sent back to the last destination it visited. Which means the closest thing to a hospital any sick astronaut sees would be staffed by Martian nurses.

Developing a protocol is essential before astronauts leave for Mars so that decisions aren't made in a crisis situation.

WHY ARE WE EVEN DOING THIS?

The cacophony of voices excited about Mars can be overwhelming, so we assembled the words of the most vocal proponents into one moderately coherent argument.

1 Stephen Hawking, 1/6/12

2 James Cameron, 10/26/09

3 Elon Musk, 3/9/13

4 Ray Bradbury, May 1996

5 Cameron, 10/26/09

23 Dennis Tito, Inspiration Mars Foundation, 2/27/13

22 Bradbury, May 1996

21 Obama, 4/15/10

MARS ONE

20 Mars One Mission Statement

19 Sonia Van Meter, Mars One Finalist 2/20/15

18 Will.i.am., 8/29/12

"It is essential that we colonize space."[1] "We've become cowards . . . As a society, we're just fat and happy and comfortable and we've lost the edge."[2] "The sun is gradually expanding. In five hundred thousand million years—a billion at the outside—the oceans will boil and there will be no meaningful life on Earth. Maybe some very high temperature bacteria, but nothing that can build rockets."[3] "It's a religious endeavor to be immortal. If the Earth dies, we must be able to continue. Space travel will give us other planets to live on so we can continue to have children."[4]

"Mars is one of your better planets, because you could actually land there, and it's close enough to get to, and it's close enough to the sun that it's not a big ball of ice."[5] "Mars is a rich destination for scientific discovery and robotic and human exploration as we expand our presence into the solar system. Its formation and evolution are comparable to Earth's, helping us learn more about our own planet's history and future. Mars had conditions suitable for life in its past. Future exploration could uncover evidence of life, answering one of the fundamental mysteries of the cosmos: Does life exist beyond Earth?"[6] "Space exploration brings out the best in us."[7]

"Now, I understand that some believe that we should attempt a return to the surface of the moon first, as previously planned. But I just have to say pretty bluntly here: We've been there before."[8] "We won the moon race; now it's time for us to live and work on Mars, first on its moons and then on its surface."[9] "Buzz has been there."[10] "It's not going to capture the imagination in the same way."[11] "There's a lot more of space to explore, and a lot more to learn when we do."[12] "The inspirational value for young people and others—education, technological spin-off, national pride, cooperation with other nations, and the building of bonds between industrial nations—all of that put together seem to me would be worth it."[13] "As with the Apollo moon landings, a human mission to Mars will inspire generations to believe that all things are possible, anything can be achieved."[14] "We'll make many technological breakthroughs . . . and our efforts will be repaid many times over. We may discover resources on . . . Mars that will boggle the imagination, that will test our limits to dream. The fascination generated by further exploration will inspire our young people to study math and science and engineering, and create a new generation of innovators and pioneers."[15] "We may gain key insights into the past and future of our own world. The promise awaits for bringing back to life portions of the Red Planet through the application of Earth science to its similar chemistry, possibly reawakening its life-bearing potential."[16]

"There's something magical about pushing back the frontiers of knowledge."[17] "This is about inspiring young people to lead a life without limits placed on their potential and to pursue collaboration between humanity and technology."[18]

"Space exploration is worth a human life."[19]

"Human settlement of Mars is the next giant leap for humankind."[20] "That's how we will ensure that our leadership in space is even stronger in this new century than it was in the last."[21] "It's that simple, that great, and that exciting."[22] "Now is the time!"[23]

Sally Ride, 2/2/03 17

Aldrin, 10/24/09 16

George W. Bush, 1/14/04 15

MARS ONE

Mars One Mission Statement 14

13 Carl Sagan, May 1993

NASA

6 NASA, Journey to Mars Overview

7 Bill Nye, 4/2/15

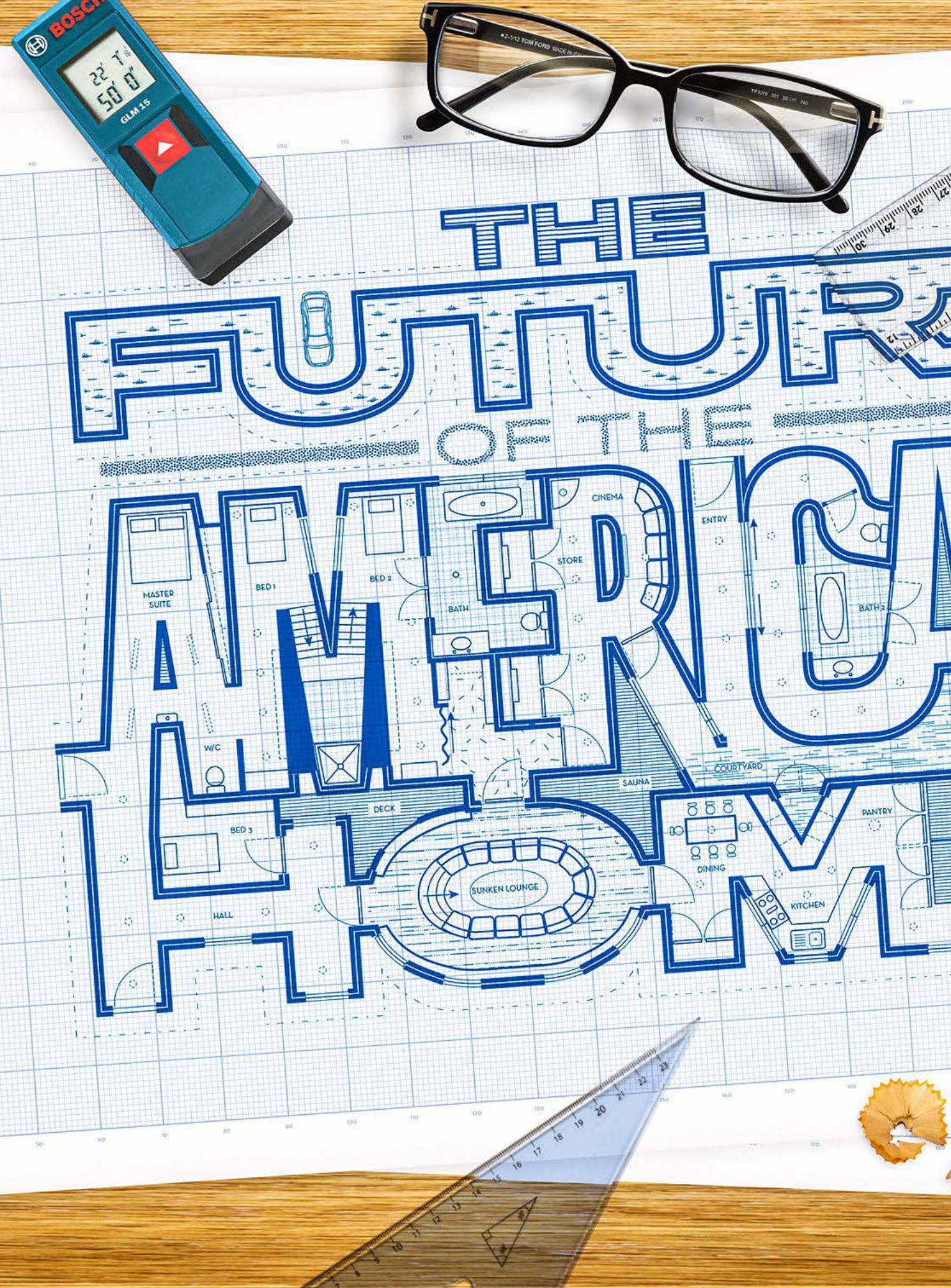
8 Barack Obama, 4/15/10

9 Buzz Aldrin, 10/24/09

10 Obama, 4/15/10

11 John McCain, 7/12/15

12 Obama, 4/15/10


BOSCH
GLM 15
TOM FORD
THE
FUTURE
OF THE
AMERICAN
HOME
MASTER SUITE
BED 1
BED 2
BATH
STORE
CINEMA
ENTRY
BATH 2
W/C
DECK
SAUNA
COURTYARD
BED 3
SUNKEN LOUNGE
DINING
PANTRY
KITCHEN
HALL

POPULAR MECHANICS

TOILETS PAGE 94
TECH PAGE 90
SOLAR PAGE 96
REMODELING PAGE 102
SECURITY PAGE 84

Owning a home grows more complicated every year. If you want to get the most out of your house in 2016, it's not going to be enough to simply fix the leaks, mow the lawn, and change a lightbulb now and then. You've got to try to understand the astonishing but confusing smart-home innovations that tumble along daily. You have to explore developments in energy efficiency, of which there have been many, but which are not simple. You have to keep your house and your family secure, but you wonder if the new high-tech security solutions make you more safe or—what with all the hackers out there—less. And, apparently, you might want to brush up on your knowledge of toilet technology while you're at it.

Fortunately for you, on the next twenty-two pages, we explore and demystify all this and more. And at the end, we address the opposite of adding technology to your home: taking your house apart and the surprises that can bring. So, dive in. Chances are you have some work to do. But it'll be worth it. You will go to bed at night confident that the walls around you are sound and secure, and you can return to the happy days when mowing the lawn and changing a lightbulb are all you need to do. Of course lightbulbs are very high-tech now, but we'll get to that in another issue.

TYPE	LUKE LUCAS	
VOL.	NO.	PAGE
192	09	83

Whether you use just one or multiple units, the Flir FX video camera allows you to keep watch on your house from anywhere in the world.

SECURITY
THE FUTURE OF THE AMERICAN HOME
2015

DIY Peace Of Mind

The past five years have done more for home security than the previous fifty: smart cameras, smart locks, even smart guns. But how do you take advantage of it all? We tested just about every product on the market to find out.

The Omniscient Homeowner

Affordable wireless cameras have revolutionized home security, and, for the author, being a parent.

BY DANIEL DUBNO

I prefer not to dwell on the smash-and-grab burglary in my home that traumatized me as a kid, but suffice it to say I wasn't left feeling very comfortable, both in our home's security and with the people responsible for securing it. (The police laughed when we insisted that they dust for prints.) Years later, when someone stole laptops from the offices at the major broadcast network where I worked, many of us chipped in to help solve the crime. With camera technology so readily and cheaply available, we could scatter hidden cameras in smoke detectors, pens, and key fobs around the office and wait for the criminals to return. So we did. And they did. Catching crooks in the act is my view of the new American way.

Recently I've enlisted the help of a new device: the Flir FX ($200). Barely the size of an ice cube, the FX belongs to a new category of security cameras. It sits unobtrusively on my living-room bookshelf, observing all and revealing nothing—except to me. The Wi-Fi-equipped device records to Flir's cloud servers, which I can access through the app on my phone at any time. If it detects motion, it will send me an alert. The FX also has an infrared camera and illuminator for recording in total darkness, and if you unplug it, the camera becomes a remote video recorder with a four-hour battery life. You can even mount it to your car, and it will automatically record whenever it senses an impact of more than 1.7 g's.

What makes the FX truly exceptional, though, is its RapidRecap system, which lets you view a day's worth of footage in seconds. The system gathers all of the motion that occurred in front of the camera and layers those video clips on top of one another, with a time stamp floating next to each potential delinquent. Hours after I set mine up, I heard wild panic and yelling from the living room, caused by a plump dove that had found its way through an open window and was circling over my screaming wife and son. Not quite the kind of home intruder I was after, but definitely worth watching a few dozen times.

If you enjoy watching people squirm, the way I do, you can also access the FX's intercom from your phone, letting burglars know that they're enjoying their last few moments of freedom before the police arrive. I didn't use that function one night this summer, when the FX captured more than I bargained for: a late-night blowout thrown by my teenage children. I was surprised they were having a party without telling their parents. They were surprised we knew all about it. In hi-def. With a time stamp.

How to Secure Your Home, 2015

According to your perceived level of threat.

THREAT LEVEL	LOW	MEDIUM	HIGH
SECURITY GOAL	To be notified of intruders or other risks—but mostly to spy on your cat.	To have a fully customizable system that monitors multiple security concerns.	To never have to think about security again.
WHAT YOU NEED	One security camera with multiple capabilities, such as the Canary ($249).	A security system cobbled together using various smart-home products.	A traditional system from a company such as ADT, Protection 1, or XFINITY.
HOW IT WORKS	These compact, single-unit security systems come equipped with some combination of security essentials: a motion-sensing camera, night vision, audio recording and monitoring, a siren, and even air or temperature sensors. A live video feed is accessible via an app on your phone or tablet, and any motion or disturbance triggers an immediate alert. Some work with other third-party security devices, but these units are best used as stand-alone systems for apartments or homes that don't require much surveillance beyond that of a main entrance.	Think of this option as a home-security buffet. Smaller motion-detecting cameras, such as the Flir FX (see "The Omniscient Homeowner"), can be placed throughout the home and allow you remote viewing access. Easy-to-install motion sensors like the Korner (three for $60) will sound an alarm and send you an alert if one detects movement at an entry point. Also falling under this category are smart lightbulbs you can remotely control, smart door locks that open via your phone's Bluetooth, and video doorbells that allow you to see who's at the door through an app.	DIY home-security technology has come a long way, but full-service security companies still provide the most robust protection. Their services are also expensive and come bundled in a two- or three-year contract that is nearly impossible to squirm out of. The good news is that most companies now have wireless options, which means no more holes in your newly renovated walls. Installation and 24/7 monitoring come standard, so if you have serious safety concerns or a lot of space to cover, it's best to leave it to the pros.
SOMETHING TO CONSIDER	Some security cameras require you to pay for cloud video storage, while others won't allow you to access live footage from your phone. Know what you're buying.	Owning smart security products from different manufacturers can leave you jumping between apps. The app IF is a third-party app that will help you streamline multiple smart products and accounts.	Because local security companies are often bought by the bigger players, quality can vary. Look for security signs around your neighborhood to see which companies are popular.

The Camera That Remembers

The next big innovation in home-security cameras is facial recognition, but as we discovered with Netatmo's Welcome, there's room for improvement.

Netatmo's Welcome is a brilliant idea—in theory, anyway. The product is built around a motion-based camera that communicates via Wi-Fi with your smartphone, alerting you to the comings and goings at a chosen entry point in your house. The difference between the Welcome ($199) and similar connected security cameras is that Welcome is capable of facial recognition, so you can train it to alert you to specific people, such as your kid or someone it doesn't recognize, and not just to any motion.

Setup is deceptively simple: Download the app, then plug in and flip over the camera, which includes 1080p video, a microphone, night vision, and a distortion-correcting field of view. After it connects to your phone, Welcome captures video of any activity along with the six seconds of footage before it was triggered, accomplished by caching video in its RAM. That stored video sits on the included eight-gigabyte micro SD card, and Welcome deletes the oldest video when it runs out of space.

Unfortunately, the device is a slow learner. Even after I "taught" Welcome to identify my wife and son, it continued sending me notifications asking me to identify them. I came to think of it as a digital Inspector Clouseau—"Aha! Caught you!"—when it was just my son returning, again, from the town pool. There are settings to control notifications and even whom the camera records once it learns faces, but my patience ran out before that happened. After a week or so I unplugged the machine, figuring I'd use it when I go on vacation. Then, at least, Welcome's notifications are likely to be far less frequent, and far more welcome.

—DAVID HOWARD

FOR THOSE WHO PREFER WOOD-TRIMMED SECURITY

AN EVEN SIMPLER SOLUTION

As a single guy with no roommates and a freight-car-sized apartment in New York City, I don't need much in the way of security—just something to tell me if someone has broken in, really. That's why the Withings Home ($200) has been perfect for me. Similar to security cameras like the Canary, the Home comes with a 1080p motion-sensing camera capable of 135 degrees of viewing, a microphone, and an air sensor, which has already alerted me several times to spikes in volatile air compounds. Good to know! My only gripes have to do with the image quality—a bit blurry—and the absence of an automatic timer to turn alerts off according to my daily schedule. I always forget to manually do that, which results in my iPhone chiming to show me the sandwich I just made two minutes ago. I do make a mean sandwich, but I don't need a recording of it.

—ANDREW DEL-COLLE

AN APP TO MAKE YOUR NEIGHBORHOOD SAFER

Nextdoor, a digital community bulletin board, is connecting neighbors across the country—and preventing crime as a result. Now even local police departments are joining.

Funny thing about the digital age: You know what your old college roommate dressed as for Halloween this year, but you've still never met the family three houses down. That's the point of Nextdoor, a popular social-networking app for neighborhoods. Once you've downloaded the app and confirmed your address, Nextdoor allows you and anyone else within a certain geographic location to share information on a secure Facebook-like feed—say someone's found a lost dog, or the Memorial Day picnic is canceled. This connectedness has also created a sort of virtual neighborhood watch, with many Nextdoor communities even helping police solve crimes. For this reason municipalities across the U.S. are starting to team up with Nextdoor.

One of the agencies to recently join Nextdoor is the Prince George's County, Maryland, police department. "The problem we have as a very large department of about seventeen hundred sworn officers is filtering information down to the mom and pop who live on Main Street," says Julie Parker, media relations director for the police department. With Nextdoor, the department can quickly post updates relevant to specific communities. But Prince George's County doesn't plan on using the platform only as a bullhorn. It's also creating a direct pipeline for citizens by assigning its community-oriented policing officers, who are already detailed to certain neighborhoods, to maintain an active presence on the app, gleaning information and responding to citizens' questions or requests. Just think of it as walking a digital beat.

—A.D.C.

THE FUTURE OF THE AMERICAN HOME

SECURITY

Is the House Key Doomed?

Smart locks are becoming increasingly popular, but will they ever completely eliminate house keys? SCHUYLER TOWNE, a lock expert and self-described security anthropologist, spends much of his time mulling over such questions. That is, when he's not testing his skills as one of America's top competitive lock pickers.

In many ways, America is a post-lock society. Most places are safe enough that home security isn't a huge concern, and in others, even the best locks aren't going to stop an intruder who really wants to break in. Locks are as much about portraying security as they are about actually keeping people out.

That might be why smart locks are taking off: They are mainly about convenience. The core feature of every smart lock is that you can open them with your phone, and they get smarter from there. But for the most part, they don't necessarily improve the cylinder or the overall security of your door (1).

I think a lot of future innovation in smart locks will be around key distribution. Digital locking and unlocking opens up possibilities. Imagine throwing a party and sending an invitation that is also a key to your apartment (2), or being able to give a babysitter a key that works only once. In fact, it might even lead to more secure behaviors, like not having to leave a spare key under the flowerpot.

The catch is that sometimes manufacturers compromise the mechanics when they add electronics. Yale Locks & Hardware once reintroduced an issue that had been solved a long time ago—its electronic locks could be picked with a paper clip. That's not good.

It's also true that power issues plague the industry. Aside from your phone possibly dying, a smart lock's digital features require electricity, and battery life has not improved since the first wave of products in the late 1990s. Ideally, if a smart lock runs out of power, it fails securely—it stays locked and can still be opened with a physical key. But isn't it ironic that the solution to a smart-lock failure is to rely on an old-fashioned key? You might end up putting one back under the flowerpot.

This is the sort of thing historians will laugh at me for, but I think in fifty years a kid will still know what a house key is. There are some innovations out there, like human-powered locks (3), that could prove me wrong, and fast. But I still feel more secure having a fully mechanical, nondigital lock (4). When I physically lock my door at night, I am comforted by that act. I don't think that's going away anytime soon.

1
Haven
One exception is Haven, a smart lock that bolts to the floor at the base of a door. When armed, it bars the door from the bottom. It's stronger than a deadbolt and ditches keys in favor of digital activation. Haven still has some hurdles—it only works on inward-swinging doors, for example—but its approach is probably the most interesting new idea in smart locks.

2
Lockitron
Lockitron might be the easiest lock to set up yet. It fits over your existing door lock, so you don't have to replace any hardware. That's important for the huge number of people who rent and are at the mercy of their landlord's skeleton key. The idea is so brilliant that the founders successfully crowdsourced the money for their first manufacturing run.

3
Kaba Mas X-10
A big problem with electronic locks is power—what happens if the battery dies? Kaba Mas sells its X-10 lock only to the government, so the company has to make it secure and reliable. Kaba's solution: The twist of an input dial generates enough power to turn the lock on long enough for a pass code to be entered. Now it needs to get into consumer locks.

4
Sunnect AP501
No one lock has combined high security with the convenience of smart-lock features, but the Sunnect AP501 is almost there. It's keyless, offering keypad or key-fob access, and it's the toughest lock around. But it doesn't yet connect to a phone app, which will be crucial if it plans on competing with other, more popular smart locks.

Smart-Home Obsession

A cautionary tale.

The obsession started when I bought my first Nest product. I have a weekend house, and I was always worried about whether I had left the heat on. So I picked up a Nest thermostat to control the temperature when I wasn't there. It was just amazing to me how well it worked. After that I had to buy every smart product known to man.

First was a Dropcam security camera (which is now owned by Nest, which is now owned by Google). I put it in my living room and was instantly fascinated with watching my empty house for hours, especially the birds outside. If a bird flew by the window, I'd get a notification and would sit in front of the computer at work and freak out. I even started feeding them. My second Dropcam I pointed at my driveway to keep an eye on the weather and anybody who would stop by. Then I would show my coworkers recorded footage of a guy plowing snow from my driveway, hoping they would think it was amazing.

From there I went to Nest's smoke detectors, a Kwikset Kevo smart-door lock, and Philips LED bulbs. Now I can remotely turn my lights on and off and even set timers. Why do I love looking at my house when I'm not there? I have no idea. Because I can, I guess. Because this is what sci-fi TV in the seventies promised we would be able to do, and now we can.

The coolest thing about the lights is that when my wife is at the house and I'm in the city, if she's not picking up her phone I use the app to put the light on strobe mode, like a Bat-Signal, and she knows to call me. In fact, my wife might be more obsessed than I am. I'm kind of okay now. I think.

—DAVID CURCURITO

HOW IT WORKS: ARMATIX IP1

- Firing .22 LR bullets from a ten-round chamber, the iP1 relies on a linked rechargeable wrist-worn watch for activation. Communication between the watch and weapon are at radio frequencies that are resistant to interference.
- The pistol has a blocking pin that will only move when it receives an authorization signal from the watch. At more than fifteen inches of separation between the two, the pin moves back into place and the gun won't fire.
- The watch requires a personal identification number before the authorization signal is sent. If the PIN is correct, "good" appears on the display, which also shows charge levels for the gun and watch.

The Plight Of the Smart Gun

Technology to prevent gun accidents exists, so why isn't it widely available?

BY JOE PAPPALARDO

For decades inventors have been trying to make guns that can be fired only by their owners, without sacrificing reliability. Stuffy industry types call them personalized weapons, but everyone else just calls them smart guns.

Most smart-gun prototypes so far have depended on biometrics (voice, palm, or fingerprint scans) to verify the owner, but none have made it to production. With the possibility of sweat or blood blocking a sensor, dependability remains a concern.

That's why German gun-maker Armatix took a different approach with its iP1 smart gun. The first production smart gun to be marketed in the United States, the $1,800 iP1 uses radio-frequency identification to safeguard the weapon: As soon as the gun loses radio contact with its accompanying wristwatch, it automatically deactivates.

The main purpose of smart guns is safety. Records kept by the Centers for Disease Control from 2013 (some of the most recent collated informa-

MY HOME-SECURITY WISH LIST

Wylie Dufresne, PM's resident culinary authority and unabashed prepper, shares some of his dream security products.

Nest Cam
Nest bought Dropcam last year, and this is the first result. It's essentially the same hardware, but like other Nest products, the Nest Cam will learn your patterns and alert you when things don't seem quite right. It also has night vision. $199 (For more on Nest, see page 90.)

Guard Dog Security Titan
A combination flashlight, 18.5-inch clubber, and stun gun all wrapped up in one medieval-looking package. And it comes with a lifetime warranty. $120

3M Safety & Security Window Film
This film can be difficult to install (best to have a pro do it), but once in place it will make breaking windows much more difficult. Bonus: It helps block the sun's rays, resulting in a much cooler house and less a/c usage. Price varies.

Arma 100
Essentially a twenty-first-century blunderbuss. It uses nitrogen to launch a variety of nonlethal payloads, such as a beanbag. Within twenty feet this thing'll leave a mark. $199

Nightlock Door Barricade
This is an aluminum device that installs in the floor at the bottom of your door and uses a removable vertical wall to keep the door from opening. It's easy to install, and there is no chance someone is going to get through it. $40

tion) show 505 accidental gunshot deaths in the U.S. for that year. And according to Johns Hopkins University, unintentional shootings are among the most preventable forms of gun violence. Presumably, smart guns could also deter gun theft and even protect police officers who lose their gun in a tussle.

But finding support for smart guns in America isn't as easy as it would seem. First, there's the politics. The National Rifle Association is notoriously prickly when it comes to anyone intervening in the gun market, so even safety technology is viewed as a potential threat. In fact, the only store to carry the iP1 stopped selling it last year after receiving hate mail and an arson threat from gun-rights activists.

Part of the reason for these fears is one tactless law. In 2002 New Jersey passed the Childproof Handgun Law, mandating that gun sellers sell only personalized weapons in the state once there are smart-gun products for sale. This all-or-nothing approach has been polarizing, so now the same politicians who passed the law are discussing how to repeal it in favor of tax incentives that promote smart guns.

Aside from politics, there's also the much larger issue: Smart guns just might not make sense. The iP1, for example, accepts only .22 LR ammunition, which is fine for target shooting but is too low a caliber for most who prize self-defense. It's also $1,800—you could buy a trio of new .40-caliber Glocks for that.

Armatix says it's working on larger caliber versions of its pistols, and as with any new technology, prices tend to come down. But street credentials still matter, and that might come only from professionals. "The holy grail of smart guns is a large purchase order from a law-enforcement agency," says Stephen Teret, director of the Johns Hopkins Center for Law and the Public's Health.

If lawmen adopt a firearm, it means they feel it's reliable enough for real-world use. Then the industry will follow. This is how the Colt .45 Peacemaker dominated the market in 1830—by first selling to the Texas Rangers and then marketing to stagecoach riders. Until this happens, though, don't expect to see a smart gun at your local gun shop anytime soon. PM

The Improvised Safe Room

We're not saying you need a full-on panic room, but having a fortified space in your house to hide out in during an emergency is never a bad idea. Here's how to secure an existing room with minimal effort.

BY CAMERON JOHNSON

1. CHOOSE YOUR LOCATION

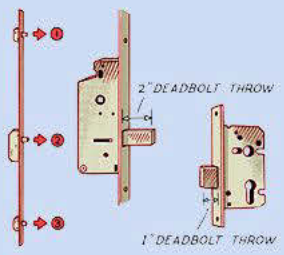
A room that everyone can get to quickly and fit in comfortably is ideal. Try to pick a space that has as few exposed interior walls as possible. If you live alone, a walk-in closet or bathroom is good. For families, a master bedroom works.

2. CONSIDER THE WINDOW

If your designated safe room is on an upper floor, having at least one window that fully opens is beneficial. A stashed-away escape ladder will allow you to exit if need be.

3. REINFORCE YOUR DOOR

Interior doors tend to have a hollow core and are easy to kick in. Replace yours with a solid wood door that uses pinned hinges and swings out. The extra resistance from the doorjamb will make it harder to kick in. When ordering the door, request it as a "slab," or non-prehung, and attach the hinges yourself.



4. GET A BETTER LOCK

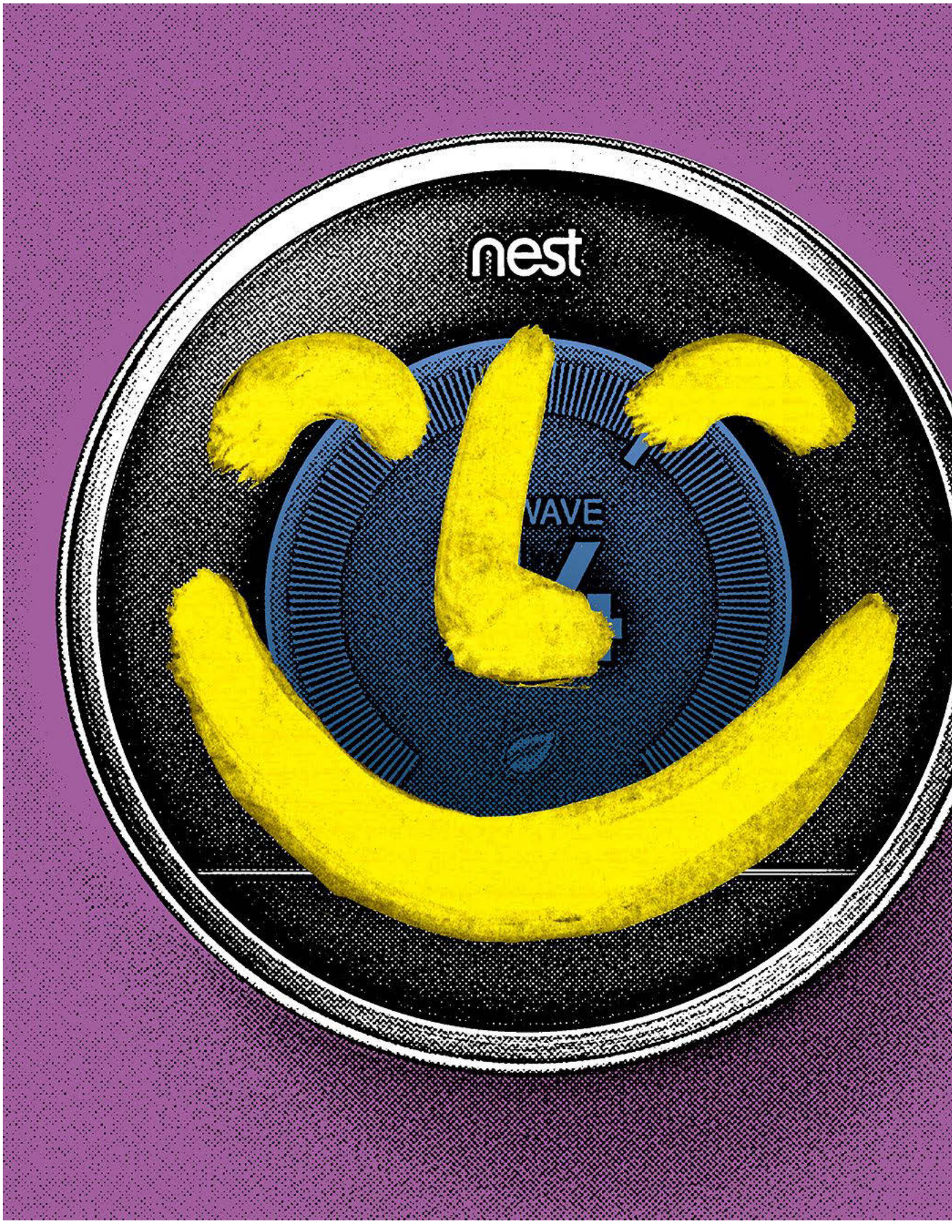
The lock on a typical bedroom door can be opened by a sneeze. Upgrade to a three-point deadbolt with a two-inch throw—that's the metal bar that fits into the jamb.

5. REINFORCE THE DOORJAMB

It doesn't matter how thick your door is if it can be forced open. Install a strike reinforcement along the jamb. The StrikeMaster II Pro ($90) comes with 2½-inch wood screws and a built-in strike plate that prevents the frame from shattering when kicked.

WHAT TO KEEP INSIDE YOUR SAFE ROOM

PHONE: Calling the police is always the first priority. CB RADIO: For when there's no cellular signal or, more terrifying, the landline's been cut. ALARM KEYPAD: If you have an alarm system in your home, an accessible keypad allows you to trigger alarms and call the authorities. FIRST-AID KIT: All the standard materials, including any medications that you or a family member can't be without, like an inhaler or insulin. DEFENSE WEAPON: Gun, putter, something. TOYS: For the kids. FOOD AND WATER: Just in case.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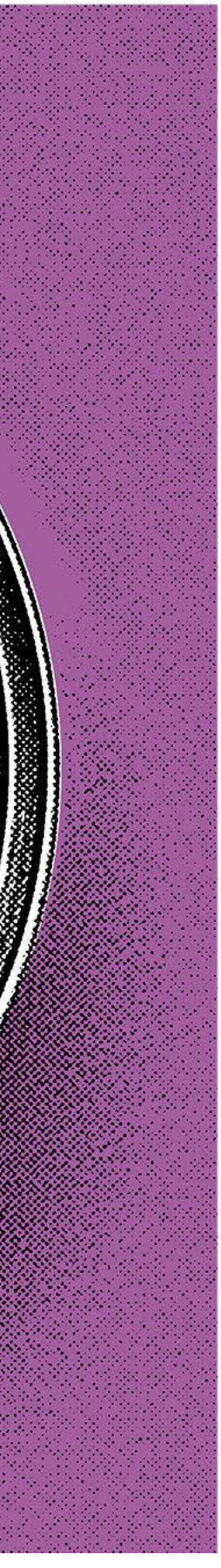


TECH

THE FUTURE OF THE AMERICAN HOME 2015

BY ALEXANDER GEORGE

Do You Want A Nest?

This Nest company, with its smart thermostats and smart this and smart that, seems to be taking off. Should you get on board? To find out, we asked a few dozen early adopters whether Nest is as great as everyone says.

My mother needed a new furnace, and she asked me about "this Nest thing, a thermostat that supposedly learns your habits and turns on and off automatically." She wanted to know: Was it good? Was it worth it? She thought I would be able to tell her. I'm the technology editor at this magazine, after all. And I do know a lot about the Nest. Its history as the brainchild of a former Apple designer who wanted to change the way we think about the mundane, functional elements of our homes. About its sales, which hit fifty thousand per month within a year of its release. But I live in a rental apartment in New York City, where you change the temperature by opening the window. So while I knew almost everything about the Nest, there was a gap in my understanding: Was it good? Was it worth it?

My mom's interest is evidence of how Nest has entered the public consciousness. Rather than buy the thermostat that her HVAC guy had in his truck, she was actively curious about the potential of a device that, in the past, would have appealed only to early adopters. Unlike the hundreds of smart-home devices that I've read about or tested over the years, Nest has become relevant to people who have, for decades, limited their technological habits to buying a new device only when the old one breaks.

The weekend after my mother's furnace replacement, I was carrying yard trimmings from her backyard to the curb for pickup. I saw her neighbor, Jim Case, bent at his hips, positioning a soaker hose. It was a cloudless 85 degrees, and he was wearing work boots covered in paint with thick socks and shorts. His ball cap had the name of his contracting firm. He had built the deck on

my mom's house.

Jim, I knew, had Nest Learning Thermostats. He mentioned it to my mom when she asked about them after replacing a/c compressors that had been ruined by Hurricane Sandy. So I asked him, the way you'd ask your neighbor about his new car: You like it? How's the mileage? It handle okay? Seriously, do you like it?

"Oh, they're great," Jim said of the two Nests in his house and the two more he'd installed at his mother-in-law's, which his wife controls remotely. Like a lot of the people I talked to who own smart-home devices, he didn't speak with the breathless enthusiasm of, say, a new iPhone owner. He didn't gush. But he had conviction. "We just love it," he said. "The heating and cooling are separate so we had to get two, because the system is a million years old. But they're great."

I asked about the Honeywell alternative that the technician working on my mother's house was pushing. "Well," he said, "it's always better to have competition." Noncommittal. Didn't want to disparage a legend, maybe. But he, a contractor, had spent hundreds of his own dollars on Nest's specific vision of the future.

Jim was the first of dozens of Nest owners I talked to. Nest is the center of the smart-home universe right now. It showed that a house is a concentration of routines that could be performed more efficiently with apps and Wi-Fi. Now the company is building an empire on the back of its sleek, round thermostat—smoke detectors, air-quality monitors, home security.

I wanted to know: What do people think? If you own a Nest anything, do you like it?

Ali Levine, an administrative assistant at Wichita State University in Kansas: "The thermostat has been great. The learn function, I initially didn't totally trust it, but it's been working just fine. I have a twenty-three-year-old furnace and air conditioner. The installation was idiot-proof. I don't think it took fifteen minutes."

Denis Lemire, up in Edmonton, Alberta, bought a Nest when it came out: "If it's smart, I probably want it. I saw the viral video, and I was first in line to preorder."

I found these people in online forums and through Twitter. I asked strangers at Apple stores (days before the company removed Nest products from its shelves because, it's rumored, Nest isn't compatible with Apple's HomeKit). I asked friends of friends. I finished every conversation by asking, "Do you know anyone else with a Nest?" Peter Leuzzi, in Chicago, tweeted a complaint to Nest's customer-service Twitter handle: "the app update is crashing my app after entering my ZIP code at setup." Leuzzi told me he bought a Nest Learning Thermostat for his hair salon. It sits behind his station, so his clients see it in the mirror. Frequent questions he gets: How much was it? ($250.) Is that thing taping us? (Sort of. It has a motion sensor and tracks movement.) Has it saved you money? (Yes. Everyone said this.)

Like a majority of Nest thermostat owners I found, he had installed it himself. His issue, wherein his app was crashing, preventing him from controlling it remotely, was something he was able to fix. The experience didn't sour his opinion of the product. "Being the first with anything, you're going to have a few glitches," he said.

I asked him, why Nest in the first place?

"I wanted to monitor my expenses, mainly in the winter," he said. "I turn it on fifteen minutes before we open, then shut it off fifteen minutes before closing. It's a welcome change. I bought it for the aesthetics and kept it for the savings."

In Atlanta Joshua Davies was among the few people I talked to who had bought and installed a Nest thermostat in a property he didn't own. Davies is a renter. He said: "I love it. I recommend it to everyone. I love the way it looks, its features, being able to control it remotely. It was the first smart-home appliance I wanted because there were other smart products circling around it. It was going to be a gateway." Then he said something amazing: "Our building actually encourages it because of the fact that it's easier to save money and reduce electricity usage."

That seemed strange. Building management that thinks the Nest thermostat is so valuable that it actually wants its tenants to drill holes in the wall and futz with wires? I called CFLane, the property management company that handles Davies's apartment. "For any community when you're renting, they're asking about utilities and costs," said Michael Zucker, a CFLane leasing consultant. "Every apartment here is metered individually. It's the only bill that's not billed through us. [With a Nest,] over the course of a single lease, you're going to break even. Much higher-end communities come with these things inside." Zucker has a Nest thermostat in his office.

The aesthetics of Nest's products kept coming up. "Futuristic," people said. "Sleek." "Slick." I asked Paul Martin, an energy-management consultant in Charfield, England, why he chose the Nest over the humdrum model his boiler technician recommended: "If it's going to be on display in your home, it has to look nice," Martin said.

> It's incredible that something with an LCD screen and firmware updates can have the timelessness of an Eames chair.

That has been Nest's ambitious goal: to improve the "unloved categories in the home," according to Tony Fadell, the CEO. After the Learning Thermostat, his company turned to the smoke detector. They call it the Protect. New territory. Life-and-death territory. Nest spent eighteen months developing the Protect and working with U.S. and international organizations to comply with safety regulations. I found people who owned a Protect. The question now was not whether they liked it, but have they ever had a problem? If I was going to recommend that my mother install one of these in her home, where it could save her life, I wanted to know more.

"You don't really interact with it much, if at all," said Davies, the Atlanta renter. "I triggered it once when cooking something. A voice comes up, says, 'We detect smoke. In ten seconds we're going to sound the alarm.' I took a bath towel, waved [the smoke] away." In England

Martin once had his Protect triggered by the weather. "We had a bit of high wind, the windows had been left open, and it had disturbed some dust, and the Protect just needed to be reset. But, of course, explaining to a panicking wife over the phone what to do is kind of harder," Martin said. "So I said, 'Just silence it.' Which you do by holding the button, and it's been fine ever since."

Davies said, "I looked up reviews and you see people who go through three Protects from false alarms, but I've had no problems. No issues whatsoever. I'm trying to figure out what people are actually doing, because I've been completely satisfied. I love it. I recommend it to everyone."

I called up owners who had had these false alarms, wondering whether the old computing adage applied: For every computer error there are two human errors, and one of them is blaming the computer.

"Last weekend I'm out, thirty minutes away from my house," said Mark Spirek, who has both a Nest Learning Thermostat and a Protect at his home outside Chicago. "I get an alert on my phone: smoke in the hallway. I freak out. No one's home. I think my house is on fire and my dog's dying. The fire department goes over and they tell me that there's no sign of fire. They ask if I want them to force entry, and I say, 'Yes. I've never had a false alarm.' It's gone off when someone is cooking, so I figure, well, it's probably going off because there's smoke. They go in, there's no smoke, no sign of anything, everything's fine. How am I supposed to trust [Nest] again?"

I heard a few similar complaints from other owners, all of whom had pets, which explains why the false alarms fried their nerves. "When you call in," said Levine, the Wichita thermostat owner who also owns a Protect and has a dog and cat, "[Nest] asks a series of questions: 'How often do you dust? Is there a vent near the Nest? How far is it from the shower?' I said to the lady, 'I don't know if this is something you're trying to say *we've* done?'"

The Nest Learning Thermostat came out in 2011, just weeks after Apple announced the iPhone 4S. Streaming music had launched in the United States, citizens were using social media to help overturn dictators in Africa and the Middle East, and Elon Musk was nine months away from releasing a car called the Tesla Model S. We were all thinking hard about what makes a piece of technology attractive, useful, even meaningful. It was a time to be thrilled by the future and the devices that would mark our arrival in a new era. Even if that spirit has faded by late 2015, the feeling still exists.

Randy Sessions, a telecommunications technician in Wichita who is "almost sixty," bought a thermostat three years ago—another early adopter. "I have my mother-in-law living with us, and she's in the house all the time. We've been out of town, and she calls up and says, 'I'm too cold.' So we can get on the app and turn it up." Sessions was one of several owners I came across who got a Nest for either their mother or mother-in-law. "I've been really pleased with it," he says.

People mentioned the tactility: the metal ring that provides just the right resistance when rotated, the curved glass that covers the numerals on its blue screen. It's incredible that something with an LCD screen and firmware updates can have the timelessness of an Eames chair.

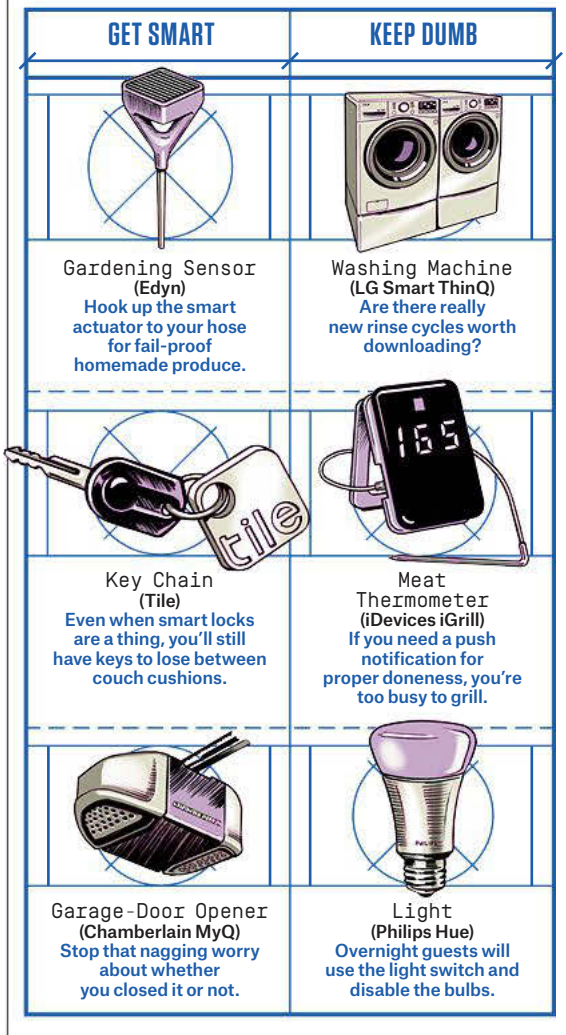
I was encountering not joy but deep satisfaction, which is probably a better aspiration for technology-makers. Non-Nest thermostats are usually the 1953 Henry Dreyfuss dial design—an icon in its own right—or white plastic boxes. An interior designer, Lisa Canning of Toronto, whose clients spend "hundreds of thousands of dollars on smart-home systems," has lived with both. "We had a huge, clunky 1970s thermostat that wasn't even retro enough to look cute," she said. "And we had a rental house with a modern thermostat. Even after reading the instructions and YouTubing, we couldn't figure out how to make it work."

Other takes on modern non-Nest programmable thermostats: "[The Nest] makes every other thermostat a gray piece of garbage." "There are instructions on the traditional thermostat I bought, but they look like what you'd get with a graphing calculator." An excerpt from Nest's instructions: "Use the bubble level to make sure the Nest Thermostat is level." Easy. That's something Nest understood from the start: If you're going to get millions of regular people to install their own thermostats, it has to be easy, it has to be fast, and they have to be satisfied with the result. Not jumping for joy—you don't need that. You just need satisfaction.

When I look at the deck that my mother's neighbor Jim built for her, it's clear that someone took care in creating it. The dark stain has retained its original color through five summers of direct sunlight, children dropping beach toys, and hurricanes. There are no errant pieces that you need to avoid while barefoot, and nothing creaks or flexes. When you're modifying your home in a significant way, you want that kind of care and attention. You want to feel like the modification was made just for you, because it fits your life. Not a lot of smart-home products are there yet. When they arrive, they'll have the kind of customers who talked to me. PM

Do You Want a Smart . . .

If an object is bigger than a quarter, someone's added Bluetooth or Wi-Fi and called it smart. Sometimes it works, sometimes it's idiotic. Here's what's worth operating from an app.



Are We Ready for A New Toilet?

TOILETS
THE FUTURE OF THE AMERICAN HOME 2015

A dispatch from the front lines of the American bathroom.

BY ANDY ISAACSON

In the summer of 2014 sewage workers in London toiled for four days to disgorge a "fatberg," a congealed lump of food grease and wet wipes the length of a Boeing 747 that had become lodged in the city's pipes. It was only the most revolting sign of a problem currently affecting many municipalities: debris caught in machinery at wastewater-treatment plants. Bathroom moist wipes, the squeegee to toilet paper's buffing cloth, make up about a third of this debris. About 30 percent of wipes are marketed as "flushable," but clearly that does not mean degradable. New York City officials have reported spending more than $18 million during the past five years replacing and repairing sewer-plant pumps, gears, valves, and screens damaged as a result of wipes.

According to global market research firm Mintel, sales of flushable wet wipes increased by 14.7 percent from 2012 to 2014, while toilet-paper sales increased only 1 percent over the same period. People seem to have determined that toilet paper alone doesn't do the job, turning to wet wipes to achieve the immaculate behind. Toilet-paper companies, looking to sweep up new customers, have launched new, invigoratingly named brand offshoots (Charmin Freshmates, Cottonelle Fresh Care) to encourage them. As of 2012 there's even a fratty, postcollegiate startup proffering vitamin E– and aloe-soaked sheets called Dude Wipes vacuum-packed in black to the fratty, postcollegiate market. But with American homeowners installing smart thermostats and smart washing machines and smart toasters, might we trade in our sewer-clogging wipes for a high-concept toilet? We might, if the toilet industry could convince us it was worth the effort. After a successful TV campaign by Japanese toilet company Toto in the 1980s, bidet-style toilets are now more prevalent in Japanese households than microwaves.

A mustachioed, thirty-year toilet-company veteran given to wearing bow ties, David Krakoff, president of Toto's Americas sales division, believes that to persuade the country of the need for a high-performance john, you first have to show people what they're missing. Last fall, he attempted to show me in Toto's Soho showroom, a spa-like haven with candles and cascading plants located between a Nike concept store and a Parisian clothing boutique on one of Manhattan's trendiest streets. Here, it is not at all unusual for a sales associate to escort a grown man to the bathroom.

And what a bathroom it is. It features Toto's latest and most impressive model yet, the Neorest 750H. Its lid opens and closes automatically—a feature Krakoff describes as a "marriage saver." It has one of Toto's famed bidet seats, which reduce the need for toilet paper by issuing water out of a retractable wand. With a remote control you can control the position, temperature, and character—oscillating, pulsating—of the stream. A blast of warm air then buffs the area dry, a strange yet comforting sensation for a first-time user. The seat is ergonomically elevated seventeen inches from the floor, can be heated to between 82 and 97 degrees Fahrenheit, and is programmable like a coffeemaker. "Everything we know how to do is incorporated into this thing," Krakoff says.

But Toto is proudest of what's under the hood. As the lid opens, a mist wets the bowl to help prevent sticking. After each flush, two powerful jets create a whirlpool effect that washes the entire surface, and a mild bleach eliminates *E. coli,* cryptospo-

Water-efficient toilets such as the Toto Neorest 750H have modifications to the siphon, the trapway, and the bowl that make water move across the bowl's surface more quickly. The higher flow rate allows these toilets to move the same amount of waste with less overall water.

ridium, and other harmful bacteria. The bowl is glazed with a hydrophilic, titanium-dioxide coating and zirconium ("Teflon times ten," says Krakoff) to slough off stubborn lime scale. Upon contact with sunlight, the coating triggers a photocatalytic process that breaks down organic substances. To kick off this process, an ultraviolet light in the lid activates after the lid is closed.

The Neorest 750H is what's known as an ultra-high-efficiency toilet, requiring only 0.8 gallons of water to flush liquids, and 1 gallon to flush solids. Since 1992 all new toilets have been regulated to use less than 1.6 gallons per flush (gpf) by the Department of Energy, but high- and ultra-high-efficiency toilets that use 20 percent less water than standard models have been eligible to receive a voluntary specification from the EPA's WaterSense program since 2007.

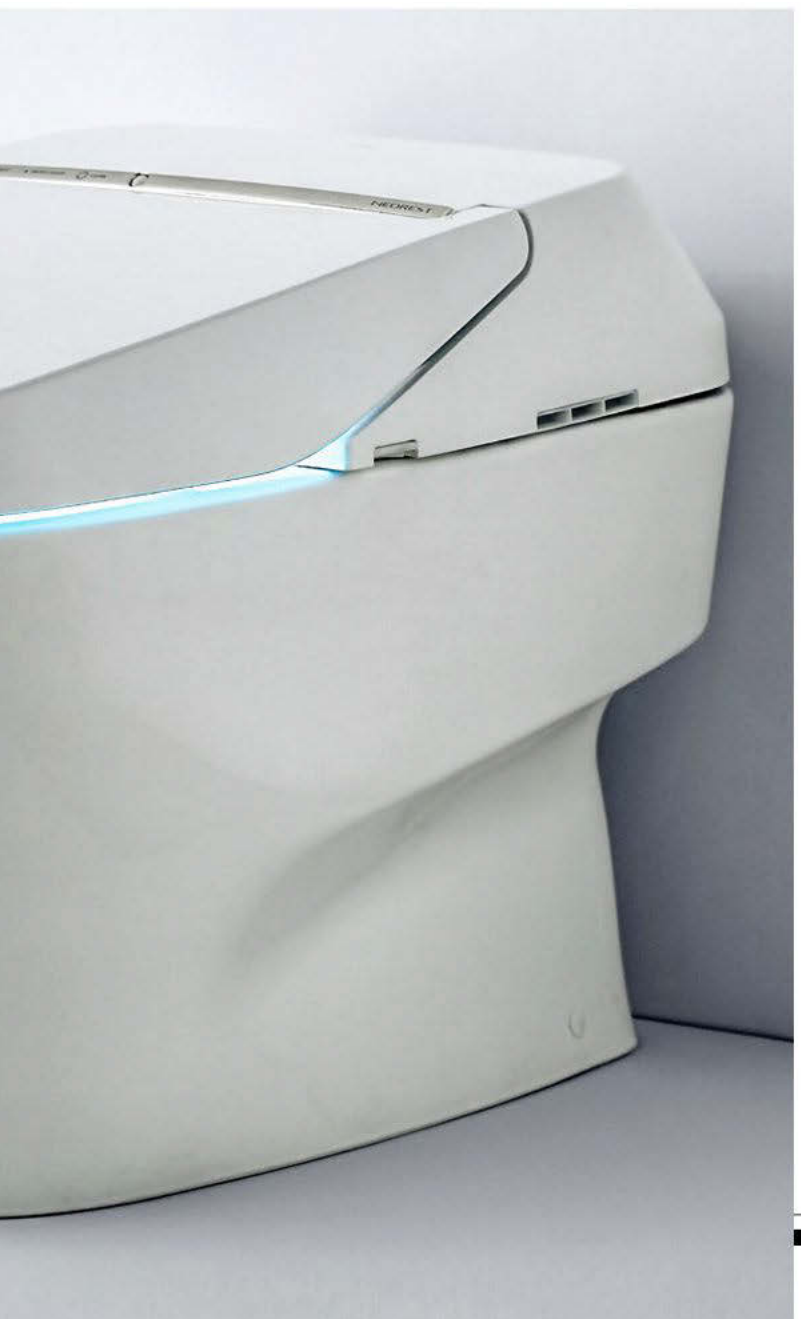
As of 2013 more than twenty-two hundred models of toilets have received efficiency labels from WaterSense, and more are being developed. At American Standard's Product Design Center in New Jersey, engineers analyze flushes using computational fluid-dynamics programs, as well as analog tests in which "floaters, sinkers, and semi-floats," such as golf balls, ground-up corncobs, and condoms stuffed with brown miso paste, are passed through stripped-down toilet bowls. ("None of us can stand miso soup anymore," says James Walsh, American Standard's vice president of chinaware.)

The EPA estimates that if every old, inefficient toilet in the U.S. were replaced with a WaterSense-labeled model like the Neorest, it would save the country more than 520 billion gallons of water per year. A single family could save more than thirteen thousand gallons per year. And while WaterSense has not specifically evaluated the effect of bidet toilets on paper use, Toto says that bidet seats require less paper overall, while effectively eliminating the need for wipes.

According to Plumbing Manufacturers International, however, only about 7 percent of American households have swapped their old toilets for high-efficiency versions, which is unsurprising given that they can be complicated to install. And though water-efficient toilets are equivalently priced to older models on average, Toto's Neorest 750H is around $10,000, and American Standard's AT200, which boasts many of the same bells and whistles, costs $4,200, leaving the cutting edge of toilet innovation far out of reach for most Americans. What's more, these high-tech toilets require nearby electrical outlets—a pricey renovation that is considered dangerous in some countries.

There is another option: Until the cost of the fanciest models comes down, which representatives from both Toto and American Standard estimate at a possible never, toilet companies are reaching out to the mainstream with scaled-back versions and add-ons. American Standard's AT100 electronic bidet seat, at $1,000, can be installed on an existing toilet. The Washlet, Toto's detachable bidet seat, costs a fraction of the Neorest. Kohler sells a sixty-five-dollar retrofit kit that can upgrade most ordinary three-figure toilets with the sensor-activated, touchless-flush technology that is integrated into its $6,340 Numi model.

Meanwhile, North American waterworks and public works associations are working with INDA (the trade association of the nonwoven-fabrics industry) to develop new flushability guidelines that will ensure that wipes labeled flushable are safe for sewer systems and wastewater-treatment facilities. A prototype wipe not yet on the market breaks up in water in less than fifteen seconds. In a decade we could all be using compostable wipes or, better, detachable bidets. Americans may never scale the heights of bathroom hygiene established by countries like Japan, but, at the very least, maybe we can match the French. PM



AND A NEW RAZOR?

I have the same facial hair at twenty-eight as I did at thirteen—a Burt Reynolds mustache with splotches on my cheeks. That means I have to shave daily. I've tried everything—the triple-blade razors that my dad swore by, even an old-time Merkur safety razor. But then I tried a good electric razor. As in $350 good. My dad hated these things, said they never got close enough, but my Braun Series 9 gives me the same results as his Gillette, in fifteen seconds. Yes, the process lacks the ceremony of a wet shave. But until I'm old enough to pull off the scruff that's in right now, I'm going to use my morning routine for important stuff, like looking at motorcycles on Instagram.

—ALEXANDER GEORGE

"There will come a time when the tech, labor, and financing are advanced enough for everyone to get on the bus," says Sungevity quality assurance specialist Killian McDonald.

SOLAR
THE FUTURE OF THE AMERICAN HOME
2015

Will Solar Ever Work?

An investigation into the murky politics of America's renewable-energy-powered future, with a little help from a solar evangelist.

To Killian McDonald, heaven is a "football-field-sized roof with a 10-degree tilt, facing south toward the sun." A twenty-seven-year-old with unruly eyebrows and the easygoing timbre of a genius surfer bro, McDonald is what you might call a solar evangelist. He seemed destined to get strapped into the "solar coaster," as he calls it, when he enrolled in an environmental science class in high school. "We made biodiesel out of used oils from the local pizza joint that made VW engines sing," he says. "We learned about fuel in dumpsters and electricity in sunlight, megawatts of power in waterfalls. It made me the worst kind of tinkerer, which is the one who cares most about repurposing and rebuilding stuff that has been discarded, trashed, or simply overlooked." Now McDonald works for Sungevity, an Oakland, California–based solar company that evaluates homes and businesses for photovoltaic panels, then provides a local installation team that drives over to mount them.

With America's dependency on fossil fuels slowing toward stagnancy, there are few industries more packed with potential than solar. And McDonald, after spending seven months "sweating in a big hat and avoiding scorpions" in the fields of Thailand, where he rehabilitated soil by pyrolyzing corncobs into charcoal, jumped on board. Upon returning to the States, he spent four

BY ERIC KESTER | PHOTOGRAPH BY MATHEW SCOTT

months on rooftops learning how to install photovoltaic panels for Grid Alternatives, a nonprofit that provides solar for low-income families. Now at Sungevity, McDonald couldn't be more optimistic about the future of solar in America. He looks at countries like Costa Rica that say they've gone completely green, and U.S. cities like Burlington, Vermont, that are making the same claim, and remains convinced that America's full transition to solar power can be measured in months rather than decades.

There is, however, a "but" to solar's progress that even optimists like McDonald acknowledge. Solar may be the future, but there are enough roadblocks for homeowners—practical, financial, legislative, and otherwise—that "people should be careful to understand their needs." This is a somewhat ominous warning. Fortunately, there are ways to confidently determine whether solar is in your future, and if that future is now.

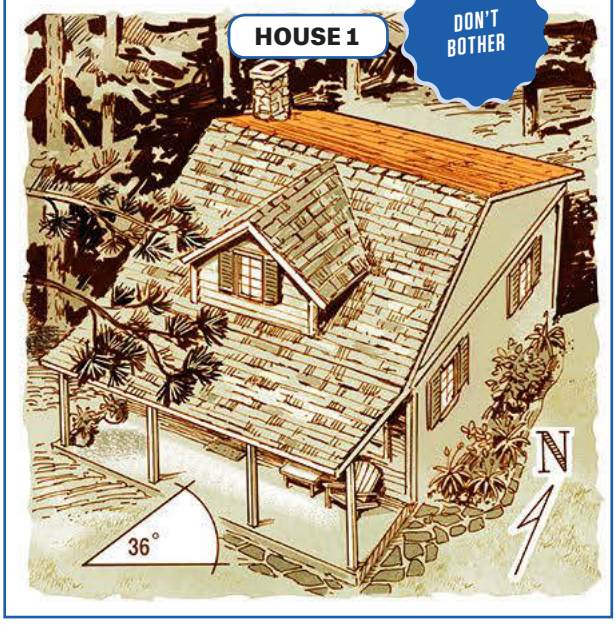
You can start by calling someone like McDonald, who before his recent promotion to an office job at Sungevity's Oakland headquarters worked as a home-energy auditor for a year. This means, if you were to call Sungevity about switching to solar energy, he would arrive at your home with a ladder, a tape measure, and a resolve to evaporate your utility bill. Usually he'd begin in the attic, searching for critical information that could reveal whether your home's structure would support the weight of solar panels. "Okay, the lumber is Douglas fir No. 2," he'd think, running a hand along a rafter, "with 2 x 4s at twenty-four inches on center." Sturdy wood, spaced only two feet apart: good.

Next, McDonald would climb onto the roof to check its sun exposure and shingles. If there were obstructions, "then he might need to have a conversation" with the homeowner about cutting down tree branches or removing regrettable roof ornaments. He'd gotten so familiar with shingles that he'd practically become a roof whisperer. "I'd think, how many layers am I standing on? How sun-baked are they?" he says. "If I lift the lip of a shingle and underneath it's much darker than what's exposed to the sun, then it's pretty old and subject to cracking and leaks. If it feels bouncy and squishy, and it feels like there's not a whole lot of grit, that's a problem too. That means the roof has had serious wear." In these cases

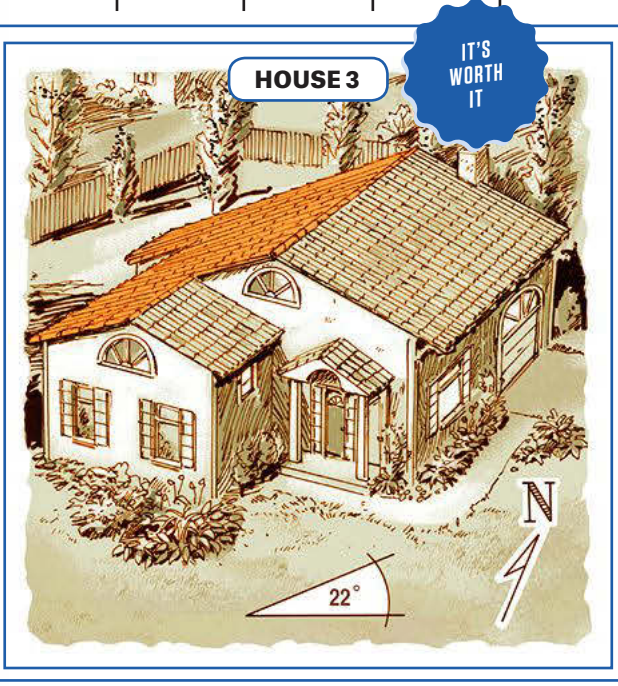
Is Your House Right For Solar?

In addition to state incentives and local sunlight, one element to consider before installing solar is whether your roof is ideally situated to receive rays. There are four key characteristics solar companies look for in the section of your roof you intend to pave with panels: [1] roofing material, [2] the azimuth, or direction the section of roof faces, [3] the roof's pitch, and [4] the hours of sun the roof gets per day. Assuming you're buying energy from a conventional utility at a cost of $0.25 per kilowatt-hour, and you've got enough roof to install the optimal number of panels, here are the savings you can expect based on what you've got.

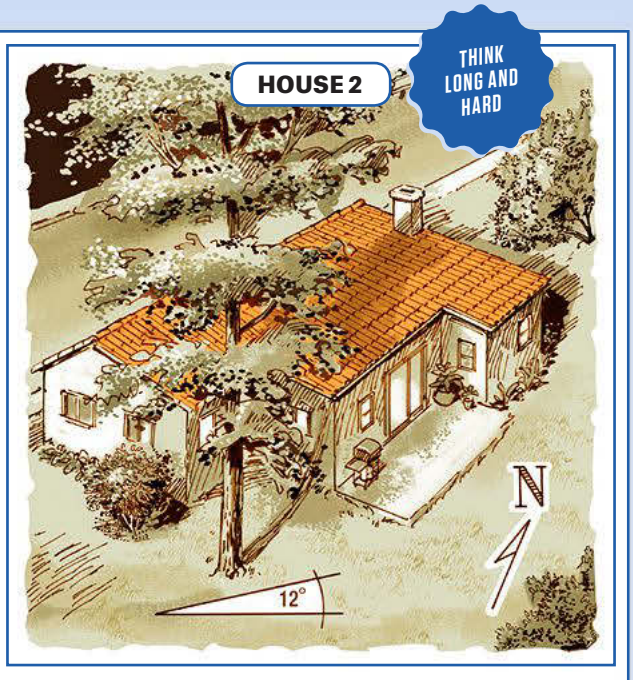
With thanks to Aamir Khan, director of training and enablement, Repower Academy.



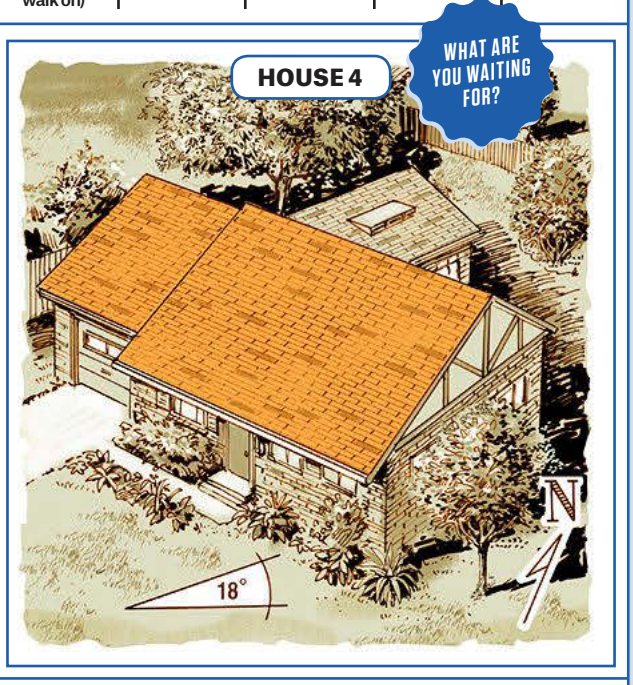
ROOF MATERIAL	AZIMUTH	PITCH	SUN-HOURS	ENERGY PRICE
Wood shake (it's a fire hazard)	North	36 degrees	3.5	$0.25/kwh



ROOF MATERIAL	AZIMUTH	PITCH	SUN-HOURS	ENERGY PRICE
Spanish tile	West	22 degrees	5	$0.16–$0.17/kwh



ROOF MATERIAL	AZIMUTH	PITCH	SUN-HOURS	ENERGY PRICE
Spanish tile (difficult to work with/walk on)	East	12 degrees	4.5	$0.18–$0.19/kwh



ROOF MATERIAL	AZIMUTH	PITCH	SUN-HOURS	ENERGY PRICE
Composite shingles	South	18 degrees	6	$0.14–$0.15/kwh

McDonald would likely recommend reroofing before any solar panels were bolted on. Otherwise the risk of the roof cracking or leaking would be "a huge liability" for everyone.

This is where the promise of solar panels becomes clouded by particulars: Utility bills can be expensive, but are they worthy of reroofing the house? According to Clean Power Research, the average solar household in America will save more than $20,000 over the next two decades, but residential solar systems run upward of $25,000. And that doesn't include any of this reroofing business.

"For a while there was this view that solar was reserved for the wealthy," McDonald says. "But the industry has gained so much traction recently because so many more Americans can afford it through new financing options."

Albert Chan, a Stanford and MIT graduate who is part of a growing sector of passionate young intellects flocking to the clean-energy-research industry, has an opinion on those options. He says that over the past few years financial innovation has been "one of the biggest trends in solar." Since 2010 the cost of residential-solar-panel installation has dropped 45 percent, in no small part due to full-service companies like Sunrun, SolarCity, and McDonald's Sungevity, which allow customers to lease solar panels for zero dollars down and a small monthly payment that's still notably cheaper than most utility bills. The companies also provide professional monitoring and maintenance for the panels themselves, which, to be fair, typically require nothing more than a garden hose to spray off accumulated dust. But the guarantee of professional upkeep offers peace of mind when it comes to more complex technical issues.

The potential downside to leasing solar panels, however, is that it makes homeowners ineligible for the juicy energy investment tax credit (ITC), a federal tax break that covers 30 percent of solar-installation cost. Often hovering around $10,000 in value and capable of being carried forward if it's not entirely used in a single tax year, the ITC is a major reason that solar installation has exploded by 1,600 percent since the credit was instituted in 2006. Leasing proponents defend their model by claiming that the value of the tax credit is absorbed by the solar installer and then passed along to the customer via cheaper prices. But then, of course, they would.

"Owning the system on your roof is how you maximize the economic benefits of solar," says Eric White, a former investment banker in the fossil-fuels sector who became disillusioned by the market's trail of negative economic and social repercussions. White's response was to cofound Dividend Solar, where he used his financial expertise to develop a hybrid financing model, one that allows homeowners to claim the ITC while also avoiding up-front installation costs. Dividend's financing model offers

the benefits of leasing (no up-front cost, peace-of-mind performance guarantees) while still allowing homeowners to own their system and the tax incentives that come with it.

With three financing models available, surely it's time for everyone to clear the roof and praise the sun god, right?

Yes and no. Potential solar buyers must keep close watch on the health of the ITC, set to expire December 31, 2016. Solar advocates are fighting for the credit's renewal with particular desperation because its loss could reverse solar's national momentum. According to the Solar Energy Industries Association (SEIA) projections, loss of the credit could cause a 57 percent decline in solar installations in 2017.

And then there's "net metering," a solar-energy process allowed in forty-four states that has enormous financial impact on the homeowner. To understand net metering, you must first understand (or, in my case, come to terms with) the fact that going solar doesn't mean you've gone off the grid. You're still very much connected to your local electrical company, and while this news is disappointing for us rogues hoping to live off the fat of the land like modern-day Steinbeck characters, it can have positive implications for solar owners for two reasons. First, it means you still get electricity during storms and at night (though being grid-bound does mean that during local power outages you're as much in the dark as your neighbors). And second, being connected to the grid means that during peak sunshine hours you can actually feed excess energy back into the system. This, technically, is what net metering is: Your electric meter spins backward in triumph as you sell back to the utility any surplus energy your panels generate. Not only that, you sell your power at retail price—if energy costs twenty cents per kilowatt-hour in your neighborhood, then you sell it to your utility at that same rate. You can't actually profit off your rooftop power plant, but you *can,* with enough sunshine, zero out your electricity bill.

It won't surprise you to learn that utility companies are not fans of net metering, and that they're fighting it on a legislative level. Their argument—and it's not without merit—is that solar users are essentially free riding off the utility grid. "Net metering is controversial," Chan told me. "You have the solar advocates and homeowners saying, 'I bought a kilowatt-hour at a certain price. If I'm selling it back I should get that same price.' But then you have the utilities saying, 'Look, that kilowatt-hour includes the cost of maintaining an electrical grid, so the actual electricity generated is half that price, with the other half being the price of maintenance.'"

Because net metering offers major financial benefits to solar users, it's become the primary target for utilities trying to clamber out of the so-called utility death spiral, a phenomenon to which most homeowners are unwittingly tethered. Essentially, as more homes and businesses switch to solar—and, according to SEIA, that's happening at a staggering rate of one every 2.5 minutes—utilities must compensate for the revenue loss by raising prices on their remaining customers, a hike that in turn encourages those very customers to switch to solar, thus beginning the cycle again. As a result, fossil-fuel-based utilities have found themselves in a battle of survival against an opponent that won't burn out for some five billion years.

The approach of the utilities has been to shift the conversation about solar power away from its positive environmental impact (an argument utilities cannot win) and toward net metering's negative social impact. The American Legislative Exchange Council (ALEC), a powerful nonprofit organization composed of conservative state legislators, has been particularly vocal on this front. In a net-metering reform proposal, ALEC points out that, because solar power is mostly adopted by wealthy households and because selling energy back to the grid forces utilities to pass the financial burden on to their remaining customers, net metering is, ultimately, a "regressive tax subsidizing the rich and neglecting the poor." The proposal cites a California study that "reported that customers who do not install net metering will be paying an extra $1.1 billion in shifted costs annually by 2020."

Some solar advocates, in a counterattack to accusations of social inequity, have taken steps to promote energy equality. Grid Alternatives, the company Killian McDonald worked for before hooking up with Sungevity, is one of many organizations that donate and install solar-panel systems for low-income communities in the U.S. and abroad.

Still, the utilities, backed by ALEC and a powerful fossil-fuel lobby, have plenty of political clout. Several states have recently passed legislation to reduce solar incentives. In 2013 the Oklahoma House of Representatives passed an ALEC-backed bill that allowed utilities to charge an additional fee to new solar-equipped homeowners. In Arizona, renewable energy opponents tied to ALEC have run an ad campaign accusing solar advocates of taking advantage of elderly residents on fixed incomes. A bitter debate over net-metering practices ensued. In just the past few years the policy push

Solar-panel engineer Albert Chan (above) and Dividend Solar cofounder Eric White (below) are both personally invested in the success of the solar movement.

For each solar proponent there are dozens of electrical linemen hanging from the millions of century-old utility poles hammered into American soil.

for additional solar surcharges has spread to over half of the forty-four states that allow net metering.

Because so much of solar's financial value depends on a state's net-metering policy, it's critical to understand whether and how fees are enforced. This isn't easy. The landscape of solar politics is constantly in flux. One reliable resource is SEIA's website, which has an informative, up-to-date section on each state's solar policies.

Once you know what policies are in place, a simple test of whether solar is right for you is to check if your home has at least two of the following conditions: (1) lots of sunshine, (2) favorable state solar policies, and (3) expensive fossil-fuel electricity. So, yes, this means you can reap solar benefits even if you live in a state with little sunshine. Eric White says that New York is one of the fastest growing solar markets in the country, which makes sense given the state's solar-friendly initiatives. Governor Andrew Cuomo made a nearly $1 billion commitment to NY-Sun, a program designed to facilitate a statewide transition to renewable energy. Combine those policies with New York's high electricity prices and the switch to solar is economically profitable despite a lack of year-round sunshine.

When coupling solar incentives like the NY-Sun program with the instability of fossil-fuel prices, you can understand why many energy experts see the widespread adoption of solar as a near-term inevitability. "Fossil fuels are extremely volatile in terms of pricing, and shake around all the time," McDonald says, "whereas solar is a nonmoving, very stable source of energy that *you* are the local provider of."

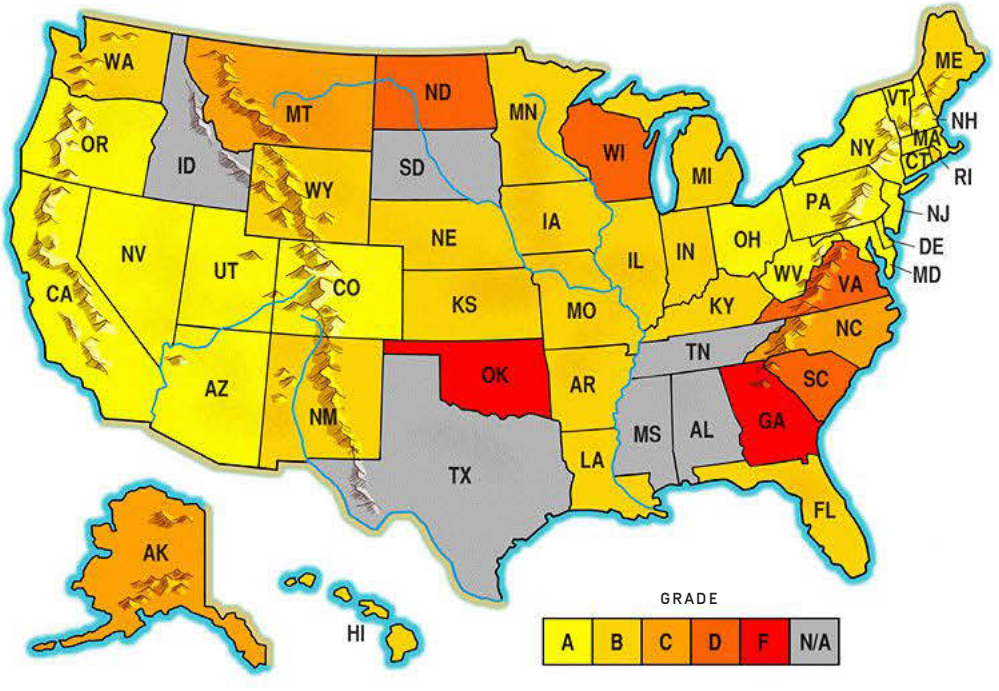
McDonald has a point: Fossil fuels are ephemeral, and the sun isn't going away anytime soon. But given the legislative muck surrounding solar, it's not hard to wonder how stable an industry can be if its financial health is so firmly bolted to the ever-shifting whims of government.

The greatest hope for the solar industry may lie in the determination of its employees, who think of their work not as a job but as a cause. They believe renewable energy is the future simply because without it, the earth itself may not have much of a future. Right now on thousands of roofs across America there are solar proponents like Killian McDonald looking up at the sun to project its path. But for each McDonald there are dozens of electrical linemen who are hanging, literally and figuratively, from the millions of century-old utility poles hammered deep into American soil.

The change will be gradual and it will be long, but it is moving in a single direction. You likely won't regret the decision to go solar in twenty years, when photovoltaic panels are as cheap and ubiquitous as cellphones, and some new country is hoarding, price gouging, or fighting everyone else over oil. The sun has about five billion years left in it. And it belongs to everyone. PM

SUNSHINE STATES

Best [and worst] net-metering practices by state, according to data compiled by the Interstate Renewable Energy Council and Vote Solar.



REMODELING
THE FUTURE OF THE AMERICAN HOME 2015

When you peel back the layers of a house, you see things. Terrifying things. Things that make you yearn for the apartment in the city where you could just call the super. Then you remember why you moved.

BY RYAN D'AGOSTINO

Home Ownership, Oh, Joy

HOME OWNERSHIP IS THIS:

Fourth of July. Outside the air is a dry 88 degrees, breeze out of the southeast, flag fluttering in its brass bracket on the front porch. My two kids are in the backyard trying to rig a zipline from the tree fort to the swing set. My wife is making iced tea and packing some boxes to store in the attic.

Me? I'm up here in said attic. I don't know how hot it is, but it feels like at least 150 degrees, and there's certainly no breeze out of the southeast or anywhere else. It's a long weekend, and I'm using the string of days to reinsulate my attic and lay down a plywood floor. I'm wearing Dickies (the ultimate work pant), a long-sleeved T-shirt (Grumpy's, a tavern in Ketchum, Idaho), and unbreathable Tyvek coveralls. Invisible flecks of pink fiberglass insulation float in the hot, dense air, looking for my skin. They sting my neck and wrists. My paper ventilation mask smells like the breath of a dog that has just eaten a tuna sandwich with a side of dead mouse. Sweat flies off my face and drips into my eyes and off the brim of my cap. I think I can hear the faint laughter of my children playing outside, but it might just be the sound of fiberglass splinters scratching my brain. I see visions of them running through the grass, or maybe that's just the deranged wasp that keeps flying into my safety goggles.

So this is home ownership, I'm thinking.

These moments happen to everyone, do-it-yourselfers or call-the-plumber types alike: You hate your house, you hate yourself for buying it, you hate heat or water or the bitter cold or whatever it is that's assaulting your dwelling this time. You just want everything to work so you can sit down and watch a meaningless baseball game on TV. And you consider, briefly, the fact that you are but a speck of dust in the universe fixing a problem that doesn't matter to mankind but that nonetheless must be fixed.

Today's problem began a couple of months ago, when senior editor Roy Berendsohn and I, with help from contributing editor Richard Romanski, installed a set of spring-loaded, pull-down stairs in my attic, the kind that disappear into the ceiling. We figured it would take the better part of a day. But when you start peeling back the layers of a house—any house, but especially one built in 1854—you find that nothing is going to take the amount of time you thought it would. You can generally take your initial estimate and multiply it by 3.5. Then add a couple of hours.

We planned to install the attic stairs over my home's main staircase. I wanted the bottom step of the extended fold-down stairs to rest

neatly on the landing at the top of the main stairs, but the location of an antique light fixture foiled my plan. The attic stairs, once unfolded, would in fact be dangling in mid-air, suspended. Obviously not an option. Nevertheless, we stared at the scene for a good hour, looking for some other way. This is one of the hallmarks of home remodeling: When an unforeseen obstacle renders your plan undoable, your brain doesn't know how to accept it at first, because you had one vision in your mind, so you spend forty-five minutes to an hour just staring.

Roy said something like, "I don't suppose you'd want to put it in the bedroom?"

Roy. Always thinking outside the vestibule. Of course! My son's bedroom had plenty of room to install and then pull down the stairs. So we walked into his room and stared at the ceiling for about an hour, trying to get used to the new plan, thinking it through. Every once in a while we'd measure something. Maybe make a pencil mark on the ceiling. That's another remodeling routine: stare, measure, mark, stare. Discuss.

Then it was lunchtime.

After the meatball sandwiches, we moved all the furniture out of the room. We hung sheets of plastic everywhere. We laid cardboard on the floor. We had one guy in the attic—at this point accessible only through a ceiling hole in another room that you reached by climbing a stepladder and hoisting yourself up through, like a gymnast mounting a balance beam—and one guy in the room. I christened the Milwaukee Sawzall my brother gave me for Christmas, cutting a perfect rectangle in the ceiling according to the stair manufacturer's specifications. And when we went up through the hole into the attic and examined the situation, this is what we discovered: My house was probably built by drunken elves using twigs and branches they found in the woods, which they cut to length by chewing them.

> In the attic we found horrors: ceiling joists with bark still on them. Homemade lumber, sometimes nailed to nothing. Scraps hammered together at bizarre angles, no two boards alike. How was the house even standing?

It was unbelievable. Ceiling joists with the tree bark still on them. Ceiling joists that weren't long enough to reach from roof rafter to roof rafter, so they were sistered to another piece of wood to complete the journey—which, of course, led to wildly erratic spacing between the joists: twenty-four inches on center, then twenty-six, then nineteen. In the corners and other oddly shaped spots, the builders had nailed together scraps of wood at bizarre angles. Sometimes the homemade lumber was nailed to nothing at all. The joists themselves were mere 2 x 4s, not the requisite 2 x 8s, or at least 2 x 6s, you'd use today. And they were 2 x 4s of unequal dimension, no two alike.

And yet: There we were. Standing in a house that itself had been standing for 160 years, through blizzards and hurricanes, through multiple generations of multiple families, through the introduction of electricity and plumbing, through ice and heat and heavy rain. Somehow, here it was.

When my home was built, many balloon-framed houses were constructed using whatever wood was available within walking distance, and the 2 x 4s in mine, uneven though they were, had been milled from solid, dense hemlock. The nails were cut steel. The more closely we looked at the house's construction—and we looked at it very closely, because you can't even stand up in the attic, so our noses were practically pressed against the floor and walls and underside of the roof—the more we realized that whoever built this house may not have had the finest materials available, but he was remarkably resourceful at assembling what he had.

Because we had sawed through two of the joists holding up the ceiling in my son's room, we had to reframe the hole, adding crossmembers to make up for the lost strength. For this we used fresh 2 x 4s doubled up to the

THE DEMOLITION TOOLBOX

The basic arsenal of equipment you need to smash part of your home into oblivion.

Ripping Bar
To remodel you need a ripping bar. It's got a cat's paw at one end for digging out nails, and a V-notch chisel and nail slot at the other. You can do everything with it from lifting shingles to dismantling wall framing.

Sawzall
There will be a lot to cut: nail-studded framing lumber and cast-iron pipe, shingles, tree branches, even roots. Only one tool handles all that, the mighty reciprocating saw. Our vote is for the famous Milwaukee Super Sawzall.

Framing Hammer
The solid-steel framing hammer is nearly unbreakable. When you're madly tearing out lumber in a confined space or driving a nail somewhere you're sure to hit the handle, you'll be glad you have this puppy.

Oscillating Multitool
Although demolition and remodeling can be a savage business, there are times when precision is called for. Enter the oscillating multitool. It cuts in impossible places, making clean slices through wood, metal, and plaster.

Sledgehammer
No remodeling and demolition kit is complete without a high-quality sledge. Don't waste money on a cheap one that will chip when it strikes concrete. Buy one that's drop-forged and heat-treated. Swing with impunity.

existing joists, perpendicular ones at either end of the hole, and 2 x 6s laid flat and screwed into the joists to pull them together. Then we hoisted the stair unit into place—backwards, of course, the first time, which necessitated pulling it down and flipping it around. We fastened it to our new framing with construction screws. Then we patched the ragged edges of the hole with joint compound and added trim to cover the seam. My sons sat in the corner of the room, giving periodic thumbs-ups. All of this took until after dinner on day two of the project, but we did it.

Two months later, when I finally had that three-day stretch provided by the Fourth of July weekend, I drove over to Ridgefield Supply, my excellent local hardware store/lumberyard/everything center, to talk to Tom Cicero, one of the store's all-knowing salesmen. Tom is a dry guy, and I could tell he thought I was insane for insulating my attic over the hot holiday weekend. He was also concerned about the fact that any flooring I put down over the insulation would crush some of the fibers, compromising its effectiveness. Tom and I finally came up with a plan that would minimize fiber smashing while maximizing the R-value of my attic insulation from whatever it was to at least nineteen, respectable for my part of the country.

I was glad I hadn't dragged Roy into this, because I'd felt bad enough that our attic-stairs project had turned into such a bear. Now, though, I wished he could see it. The attic was starting to look like something. Fresh, pink clouds of insulation in tidy rows, and a network of plywood creating a sturdy floor for storage. I was proud, but I was also drenched and felt like I'd been clocked in the knees and worked over with wet sandpaper.

A half-hour shower later, I walked outside. The temperature was pushing 90, but it felt cool and crisp after hours in the hot attic. I joined my boys for some backyard soccer and an intense game of monkey in the middle. Inside, my wife was marinating some steaks for dinner. I lit the Weber, poured myself a drink, and sat on the picnic table admiring some bugs my six-year-old son had collected and put in his pocket. And I thought, this is what home ownership is. PM

The Physics of Insulation

Fiberglass insulation is simple to install, but it's not foolproof. Understanding how it works will help you avoid the very avoidable mistakes that could render all of your hot, sweaty, miserable work useless.

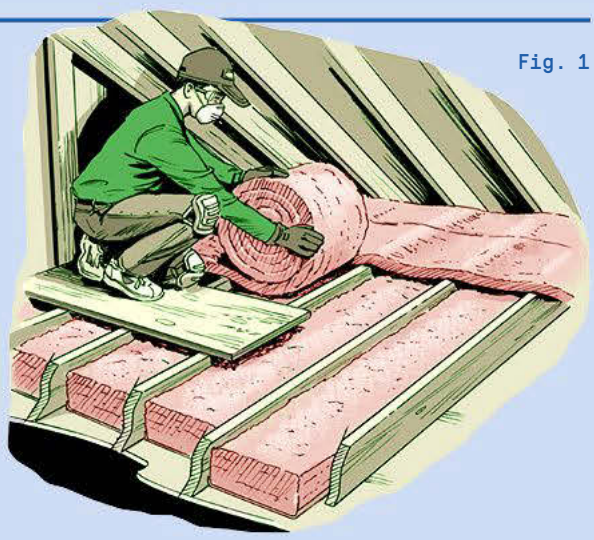


Fig. 1

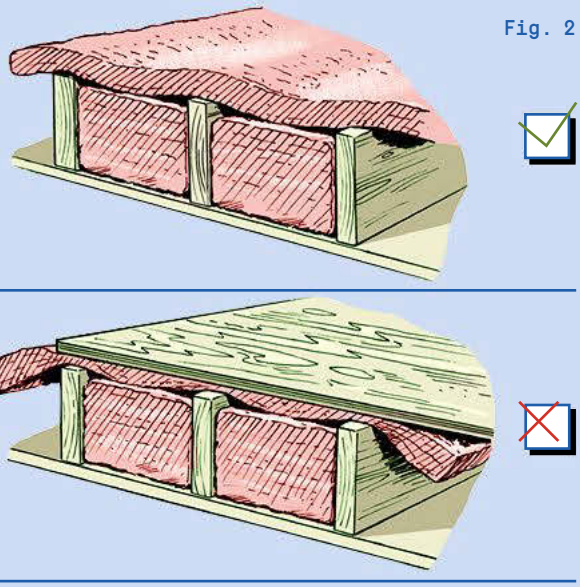


Fig. 2

Installing fiberglass insulation in an attic may be a basic job, but the material itself is surprisingly sophisticated. "With glass fiber, you can control all its properties—thermal, chemical, and mechanical," says Marcus V. A. Bianchi, senior building science program lead for Owens Corning. When glass fibers are woven into a roll or batt, they trap millions of tiny, irregularly shaped air pockets. Air, being a gas, is a poor conductor of heat energy. These pockets work together to block the three forms of energy movement: conduction (energy moving through a solid), convection (energy moving through a gas or liquid), and radiation (energy movement in the form of a wave or particle, like light).

"If people have any hope of realizing the full potential of the insulation, they need to understand the basics," says Bruce Harley, an engineer at CLEAResult, a firm specializing in energy efficiency. **The first step, he says, is sealing.** Insulation is porous, and air moving through it lessens the R-value, or resistance to heat flow. Use spray foam around wires and pipes and aluminum flashing. Use 100 percent silicone caulk to seal gaps around chimneys. Rigid foam board can cover holes at plumbing and duct chases or soffits over kitchen cabinets, and duct mastic seals leaky air-conditioning ducts.

When everything is sealed and you've insulated the bays between each joist, **a second, perpendicular layer catches stray leaks** [Fig. 1] and increases the R-value. Just be sure to **avoid crushing insulation with flooring** [Fig. 2]. If those tiny air pockets are compressed, hot air can pass freely through that part of the material, rendering the rest of it useless.

And if you don't have enough insulation to cover those last few square feet? Buy more. "Small gaps have a disproportionately large effect on R-value," Harley says. **The thickness of the surrounding insulation won't make up for a gap.** "Think of the hull of a boat," he says. "It's great to have a thick hull. But if there's a hole in it, it's the hole that matters."

—ROY BERENDSOHN

Keep It Out of Your Nose

Few jobs are less fun than insulating. Don't make it worse by hurting yourself—or your house.

DO

- ☑ Use kneeling boards to support yourself. Avoid perching on joists.
- ☑ Wear a dust mask, protective eyewear, kneepads, and coveralls or a long-sleeved shirt.
- ☑ Beware of nails protruding from above and below.

DON'T

- ☒ Cover recessed light fixtures with insulation that is not rated for insulation contact.
- ☒ Damage fragile cloth-covered wiring.
- ☒ Block eave soffit vents.
- ☒ Use insulation as an exfoliant.

Don't Get Burned

Dangerous and potentially deadly counterfeit products, from extension cords to cell phones, are purchased every day.

Take this extension cord, for instance. If you bought it "on the cheap," you could be... well, playing with fire. Fake products are made without safety standards, and they put you and your family at risk. Stick with reputable products from trusted sources and you won't get burned.

Counterfeits Hurt.
You Have the Power to Stop Them.

Protect yourself from counterfeit products.
Visit **NCPC.ORG/GETREAL**

NATIONAL CRIME PREVENTION COUNCIL

BJA
Bureau of Justice Assistance
U.S. Department of Justice

Scan this code to view more

PROJECT

BUILD YOUR OWN STAND-UP DESK

Sitting down is not good for you. It's time to give in. It's time to stand up.

DESIGNED BY RICHARD ROMANSKI

For proper ergonomics, build your desk at a height that places your sight line within the top few inches of your screen.

THE SWITCH

BY ALEXANDER GEORGE

One Sunday, under cover of darkness, I came to the Popular Mechanics offices to set up my standing desk. I put my monitor and keyboard on the $25 worth of Ikea products that, after weeks in hiding, I'd finally assembled the Friday before with the help of our senior home editor, Roy Berendsohn. I was ready to broadcast my commitment.

Before I set it up, the idea of using a stand-up desk felt pretentious—a conspicuous expression of self-improvement, the ergonomic equivalent of watching your friends order fries and shakes, then asking the waiter if you can get a turkey burger without the bun. But the desk was loved, and not just by me. People smiled while saying that they'd heard about the benefits and wanted one for themselves. Roy told me about a time he stood during most of a long-distance flight to alleviate his back pain, and that this setup looked like it could provide the same benefit. Hell, our deputy editor even ended up getting the exercise ball he said he'd been wanting to use as a chair. (He lasted only two days, though.)

Six months in, I'm still not fully acclimated, but the benefits are clear. I thought it was psychosomatic, but I've since heard from other converts that standing properly (ears in line with your shoulders, a physical therapist friend told me) actually helps you focus. I no longer dart between Twitter and the article I'm editing. Standing, somehow, eliminated that. My posture is better, and the slight ache I sometimes feel in my feet is worth it. I do take occasional breaks, but their duration decreases every day. As does my nostalgia for sitting down.

PHOTOGRAPH BY BEN GOLDSTEIN

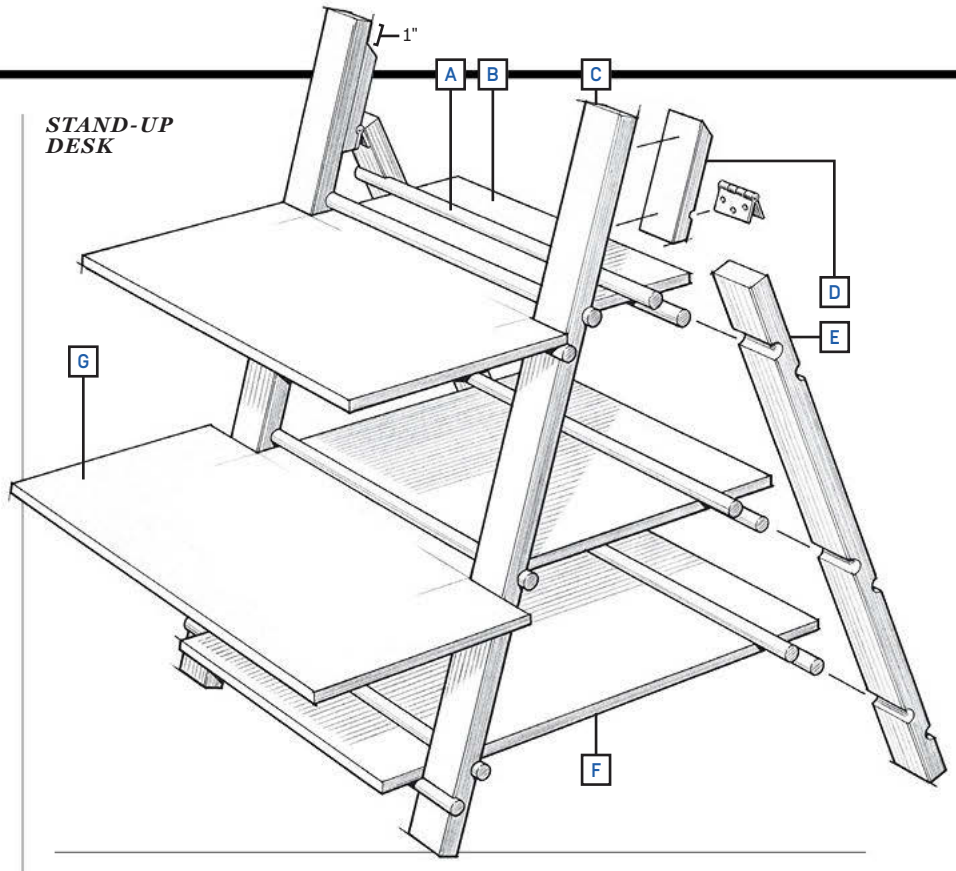
THE DESK

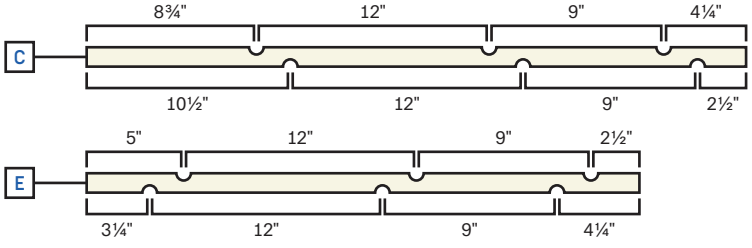
BY RICHARD ROMANSKI

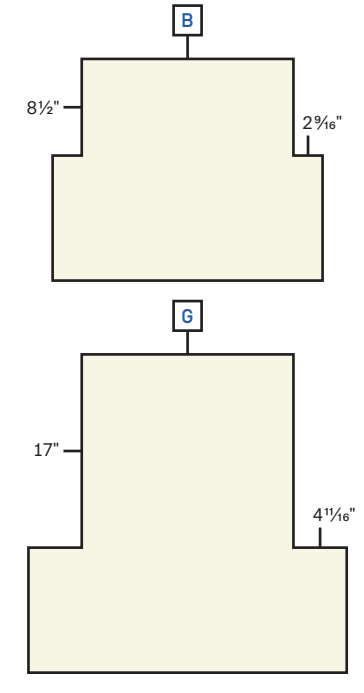
This stand is proportioned to fit atop a 29-inch-tall desk. If your desk is a different size, you can simply adjust the position of the stand's cross supports and shorten or lengthen its A-frame uprights. When the stand is not in use, just slide out the shelves, fold the uprights together, and tuck everything away.

MAKE THE PIECES

- Begin by crosscutting the poplar uprights and hinge blocks to rough length. Rip them to 2⅝ inches wide, and plane to the finished thickness.
- With a miter saw, crosscut all pieces to the finished dimension. (Use a stopblock on the saw to ensure that the pieces are cut to consistent lengths.)
- The dowels that form the cross supports for each pair of uprights are seated in shallow half-round grooves. To make these grooves, use masking tape to hold the front uprights together. Do the same for the rear uprights. For each pair, use a square to align the pieces 1, and mark the centerlines for the holes according to the drawing at right.
- Set up a fence on a drill press with an installed brad-point drill bit. Take two pieces of scrap poplar, clamp them together, and mark straight across them to indicate a centerline. Use those pieces to position the drill-press fence so that the bit comes down centered between the test pieces. When the fence is securely positioned and clamped to the wood, make a test bore. Mark the bit's centerline on the drill-press fence.
- Take the paired front uprights and align the first centerline you previously marked on them with the line you just made on the drill-press fence. Clamp the uprights to the fence and bore the first hole. Move the uprights down and reclamp them by the second hole, and so on. Repeat the process for the rear uprights.
- After you've bored three holes in each pair of uprights, separate them, retape them with the back of the sides in the center, and repeat the hole-boring procedure above 2. Repeat it one more time to produce the half-round hole in the hinge blocks.
- Next, plane or saw away any tearouts caused by the brad point exiting the edge of the uprights.
- Cut the dowels to length on the miter saw.
- Rip and crosscut the MDF panels using a circular saw. For the top and center panels, cut each notch on the table saw 3. Finish these notches with a saber saw.
- Sand the uprights and the hinge blocks





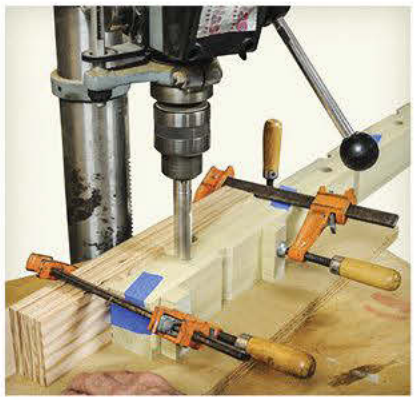


MATERIALS

Key	No.	Size and description
A	12	¾" dia. x 24" cross supports
B	1	½" x 19½" x 23¾" top panel
C	2	1" x 2½" x 34" front uprights
D	2	1" x 2½" x 5¼" hinge blocks
E	2	1" x 2½" x 28½" rear uprights
F	1	½" x 18⅝" x 25" bottom panel
G	1	½" x 28" x 28" center panel
Supplies		
1		⅝" x 6" x 72" poplar
1		½" x 4' x 8' sheet ultralight MDF
6		¾" x 48" dowel rods
1		pkg. (2 pcs) 2½" x 2½" Hillman No. 852844 stainless-steel door hinges
1		pkg. (56 pcs) No. 6 x 1¼" Hillman 823628 stainless-steel oval-head Phillips screws
1		pkg. (18 pcs) bumper pads

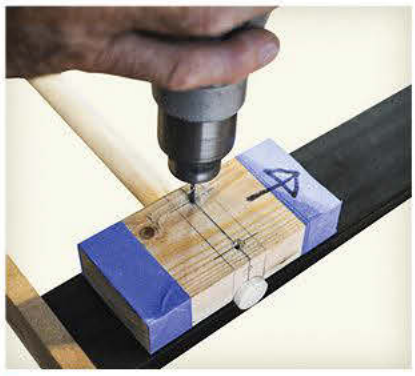
ILLUSTRATION BY GEORGE RETSECK

1 | Tape the uprights together, use a square to align them, and mark each hole location.



2 | Clamp the uprights to the drill-press fence before boring the center holes.

3 | Instead of a circular saw, cut the notches in the MDF panels on a table saw.



4 | Make a pilot jig from a scrap block to use before further securing the dowels.

5 | The dowels are glued, but you'll also want to fasten each with four screws.

with 120-grit sandpaper, followed by 180- and 220-grit. Lightly sand the dowels with 220-grit sandpaper.

- Stain both sets of uprights and hinge blocks, and apply two coats of clear satin polyurethane to them. Apply one coat of finish to the dowel rods and two coats to the MDF panels.

ASSEMBLY

- It doesn't matter whether you begin the assembly process on the front or the back of the uprights. The most important thing is to ensure that each dowel is square to the upright and that each upright is parallel to the one opposite it. You can accomplish this any number of ways. You can use a framing square to check the position of the dowel relative to the upright, or you can build yourself an assembly jig out of plywood and a couple scrap pieces of wood.
- Fasten each dowel to an upright with a small glob of carpenter's glue. When the glue has cured, bore two pilot holes through the dowel. I used a small block of wood with a half-round groove and a pair of predrilled holes to help guide the drill bit 4.
- Affix the dowels to the uprights by driving a pair of oval-head screws at each connection 5. When three dowels have been glued and screwed on each of these uprights, glue and screw the dowels on the opposite side.
- Fasten the hinge block to the front uprights with four No. 6 1¼-inch wood screws. Use the screws that come with the hinge to fasten the front leaf of each hinge to its hinge block. Swing the back uprights open and fasten the rear hinge leaf to the rear upright. Attach the self-adhesive rubber feet (bumper pads) to the uprights.
- Slide the panels into the uprights and lock them in position by spreading the uprights apart until you feel a slight pinching action on the wood.

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Periodicals postage paid at N.Y., N.Y., and additional entry post offices. Canada Post International Publications mail product (Canadian distribution) sales agreement no. 40012499. CANADA BN NBR 10231 0943 RT. POSTMASTER: Send all UAA to CFS. (See DMM 707.4.12.5); NON-POSTAL AND MILITARY FACILITIES: send address corrections to Popular Mechanics, P.O. Box 6000, Harlan, IA 51593. Printed in U.S.A.

EDITORIAL & ADVERTISING OFFICES:
300 West 57th Street,
New York, NY 10019-3797

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xNo

✓Yes

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TIME CAPSULE

A project to build with your children.

DESIGNED BY TED KILCOMMONS

Materials

QTY.	DESCRIPTION
1	3½-inch-diameter PVC pipe
1	3½-inch PVC end cap
1	3½-inch PVC test plug
1	Container each PVC primer and cement
1	Can spray paint

Instructions

parent only
parent and kid
kid only

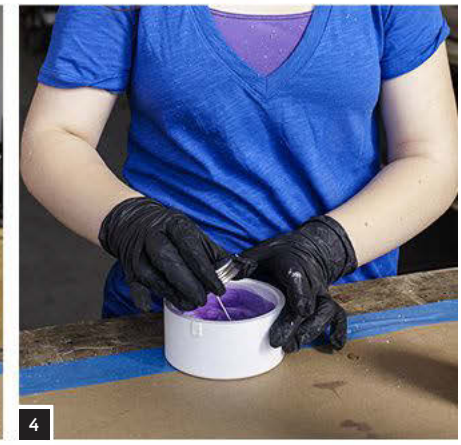
- **1.** Measure and mark off with a Sharpie the length of the pipe necessary to hold your contents. We chose 14½ inches.
- **2.** If the child is at least 12 years old and has some experience, with careful adult supervision she can use a miter saw to crosscut the pipe. If not, a standard eight-point carpentry handsaw is a safe alternative.
- **3.** Apply PVC primer to the end of the pipe and on the inside of the end cap. (Be sure to open the windows for ventilation.)
- **4.** Using the applicator tool, spread a thick layer of PVC cement onto the end of the pipe, and a thin layer on the inside of the end cap.
- **5.** With the PVC pipe upright, tap the end cap on with a dead-blow hammer or mallet. Twist the end cap slightly to evenly distribute the cement, then finish tapping the cap until it is firmly seated.
- **6.** Fill the time capsule with whatever you like, preferably nonperishable. Be sure to include something that indicates the date of the contents.
- **7.** Insert the test plug into the pipe and wind the wing nut until it is firmly tightened.
- **8.** Spray-paint the capsule.

Turn the page for the finished product and schematic diagram


1


2


3


4


5


6


7


8

PHOTOGRAPHS BY FRANNY AND ALBERT

SEE PREVIOUS PAGE FOR INSTRUCTIONS

POPULAR MECHANICS FOR KIDS

OUR BUILDER, Amanda Bonavita, a 12-year-old from Staten Island, New York, is a participant in the FIRST Robotics Competition. The nationwide tournament encourages kids to pursue careers in engineering and technology.

PROJECT NOTES

TIME CAPSULE!

A project to build with your children.

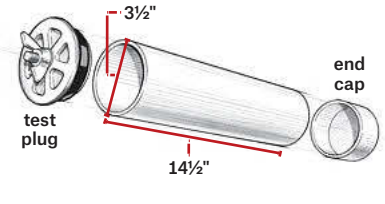
DESIGNED BY TED KILCOMMONS

Difficulty: EASY | REASONABLE | HARD

Time: 30 minutes **Ages:** 6+

THE DECISION TO USE PVC plumbing pipe for our capsule was obvious. It's tough and moisture resistant. The only problem was how to seal it. PVC is meant to be glued together, but that would make it difficult for the person finding the capsule to get at its contents. Cutting the capsule open would mean cutting whatever was hidden inside. We discussed various schemes for building a hatch—and even a see-through portal made of clear acrylic sheet—but they were all bulky, hard to build, or expensive.

Then we found our solution. The test plug we sealed the capsule with is designed to be used by plumbers to pressurize and test a home's plumbing system. When you tighten its large wing nut, you force the rubber ring against the wall of the pipe, making an airtight seal. Perfect for a time capsule.



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